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CEREAL FEED USE IN THE THIRD WORLD: PAST TRENDS AND PROJECTIONS TO 2000

J. S. Sarma

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CONTENTS

Foreword

1. Summary 9

2. Introduction 12

3. Cereal Feed Situation in 1980 15

4. Trends in Cereal Feed Use 20

5. Growth in Cereal Feed Use in Taiwan and the Republic of Korea 30

6. Dynamics of Demand for Food and Feedgrains in Selected Developing Countries 35

7. Projections of Cereal Feed Use in Developing Countries 41

8. Conclusions and Policy Implications 47

Appendix 1: Data and Methodology 53

Appendix 2: Classification of Countries Selected for the Study 56

Appendix 3: Supplementary Tables 60

Bibliography 67

TABLES

1. Estimated sources of livestock feed in the world 14
2. Distribution of cereal feed use, by region, 1980 17
3. Output of meat, milk, and eggs in livestock output units and cereal feed use, 1980 18
4. Distribution of cereal feed use by region and commodity, 1976-80 average 22
5. Trends in the feed use of grains, by region and commodity, 1966-70 and 1976-80 22
6. Annual growth rates of use of brans as feed and output of cereals, by region, 1966-70 and 1976-80 23
7. Regional distribution and trends of output of livestock products, 1966-70 and 1976-80, and distribution of population, 1980 23
8. Cereal feed use, classified by level and growth of per capita income and growth of livestock output, 1966-70 and 1976-80 26
9. Rate of growth of use of cereals for food and feed, by region, 1966-70 and 1976-80 27
10. Exports, imports, and net trade in coarse grains, 1966-70 and 1976-80 averages 27
11. Ratios of prices received by farmers for poultry and pigmeat to maize, selected countries, 1967-80 29
12. Average production and trade of cereals and livestock products, feed use, per capita income, and population, Taiwan, selected years 32
13. Per capita consumption per year, Taiwan, selected years 32
14. Average production and trade of cereals and livestock products, Republic of Korea, selected years 33
15. Per capita consumption per year, Republic of Korea, various years 34
16. Three scenarios for income elasticities of demand 37
17. Projected growth in food and feed use of cereals, 1980-2000 and average income elasticity of demand for food and feed, selected countries 39
18. Cereal feed use projections under alternative assumptions, by region, 1990 and 2000 44
19. Projected cereal feed use in 75 selected countries, by per capita income groups, 1990 and 2000 45
20. Classification of developing countries by per capita income, income growth, and livestock output growth 56
21. World cereal feed use and total output of cereals by type, 1980 60
22. Cereal feed use by type, 1980 60
23. World livestock numbers, 1980 61
24. Trends in cereal feed use, by region, 1966-70 and 1976-80 61
25. Cereal feed use of grains and brans and by-products, by region and commodity, 1966-70 and 1976-80 62
26. Cereal feed use and total livestock output, by region and subregion, 1966-70 and 1976-80 63
27. Production of compound feed, selected developing countries, 1974-76 average and 1980 63

ILLUSTRATIONS

28. Income elasticity of demand for cereals and livestock products, selected countries, 1980 and 2000 64

29. Ratio of foodgrains to food and feedgrains, selected countries, 1980 to 2000 65

30. Selected developing countries with cereal feed use exceeding 500,000 metric tons, 1980 65

31. Cereal feed use projections under method 1, 1990 and 2000 66

1. World distribution of cereal feed use by crop, developed and developing countries, 1980 15

2. Trends in feed use of cereals in the study countries, by crop and region, 1966-70 and 1976-80 21

3. Growth rates of cereal feed use and livestock products output, by region, 1966-70 and 1976-80 24

4. Trend cereal feed use in 1980 and projections to 1990 and 2000, by region, based on projected livestock output 45

FOREWORD

Use of cereals for livestock feed is growing rapidly in developing countries and is reaching significant proportions. This fact has profound implications for food security of low-income people, employment, and the size of markets available to exporters of cereals. However, developing countries vary greatly in their pace of growth in the use of cereals for feed, even within similar income groups. J. S. Sarma analyzes not only the underlying causes of the rapid growth in cereal use for feed, but also the extent of participation among countries and some of the reasons for the variation. From this analysis comes an understanding of the forces driving future usage and a basis for understanding and modifying the projection of future feed use, which he provides.

Sarma's work continues a stream of IFPRI research concerned with the analysis and projection of global forces of supply and demand for food. It is a sequel to Research Report 49, *Livestock Products in the Third World: Past Trends and Projections to 1990 and 2000,* which provides the background on livestock supply and demand in developing countries essential to understanding the complexities of feed utilization. *Food in the Third World: Past Trends and Projections to 2000,* Research Report 52, also recently published, analyzes past trends and projections of the supply and demand for basic food staples. Because of the rapidly growing importance of the use of basic food staples as livestock feed, and much greater uncertainty about the key variables determining feed supply and demand, Sarma's in-depth analysis is of particular importance.

An intimate knowledge of basic data sources and their problems is essential in dealing with the particularly imprecise data on livestock and feed sectors in developing countries. Sarma brings to this task an important set of skills. He was formerly chief executive officer of the National Sample Survey Organization in India and, prior to that, head of the Directorate of Economics and Statistics, Ministry of Agriculture, Government of India. He has also served as a member of the FAO Statistics Advisory Committee.

Particular note should be taken of the period 1966-80, which is used as the data base for growth rate projections in this report. Questions have been raised on whether this is an appropriate base period, for, by past standards, most of this period was one of high growth in per capita incomes in developing countries, which in turn led to a rapid rise in livestock consumption. Subsequently, however, because of recession and protectionism in the Organization of Economic Cooperation and Development countries and mounting debt repayment problems, economic growth in the developing countries has slowed down. On the one hand, using data from the period of rapid growth could lead to overestimation. On the other hand, one may reasonably argue that the development process in developing countries should accelerate as trained people and institutional capacity expand, thus leading to economic recovery and better economic performance in the coming years. Thus projections based on the 1966-80 trends would be more likely to reflect the effects of overcoming current structural problems and returning to the underlying process of growth.

Finally, the importance of livestock feed issues to traditional global concerns about food security and employment have not been generally recognized. We at IFPRI hope that Sarma's seminal piece will stimulate a large amount of additional analysis and hence a rapidly improving basis for policy in this crucial area.

John W. Mellor

Washington, D.C.
December 1986

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1

SUMMARY

Use of cereals for livestock feed in developing countries has increased much faster than direct food use during the last two decades. Cereal feed also grew faster than production and consumption of livestock products, such as meat, milk, and eggs; and projections to 1990 and 2000 indicate that with rising per capita incomes, these trends are likely to intensify. Many of the developing countries are meeting the increased demand for livestock products through accelerated domestic production. Much of this increase in production has occurred outside the traditional livestock sector, which in turn has resulted in a rapid rise in the derived demand for cereal feed.

Moreover, livestock (including poultry) production is an important source of rural income and employment in the Third World. When it is based on labor-intensive technology, its development helps meet equity objectives by contributing cash income to small farmers and improving their nutrition. Because an assured supply of feed is an essential prerequisite for this development, the use of cereals for feed will probably continue to grow rapidly.

In 1980, about 680 million metric tons of cereals, including by-products, were used as livestock feed in the world. The developed countries used about three-fourths and produced nearly two-thirds of the global livestock output in that year. The remaining one-fourth was fed to livestock in developing countries (including China). Among the cereals used as feed, three-fourths of the world total was coarse grains, especially maize and barley. About 82 percent of coarse grains produced in developed countries was fed to livestock, whereas only about 46 percent went to feedgrains in developing countries.

In 1980, Third World countries (excluding China) used about 100 million metric tons of cereals as livestock feed, of which less than two-thirds was coarse grains and the balance was divided between paddy and wheat. About 85 percent of paddy and 77 percent of wheat were in the form of by-products, mainly bran. For cereal feeds as a whole, by-products constituted a little more than one-third of the total.

Among the developing regions, Latin America used the most cereals for feed—about 43 million metric tons in 1980, of which 86 percent was coarse grains. Asia accounted for 30 percent, nearly half of which was paddy and rice by-products. Sub-Saharan Africa used the least, only 4 percent of the Third World total.

Between 1966-70 and 1976-80, the use of cereal grains and by-products as feed in the countries studied increased by 57 percent, an average growth rate of 4.6 percent a year. During the same period output of meat, milk, and eggs increased at an average annual rate of 3.4 percent. The rate of growth in feed use outstripped growth of livestock output in all regions.

The increase in cereal feed use was particularly rapid in Taiwan and the Republic of Korea, both newly industrializing economies, where income was growing rapidly and per capita incomes were moderately high. In these economies, where consumption of livestock products increased rapidly, domestic production based on imported feedgrains rose to meet the demand. The amount of feed used per unit of livestock output rose continuously in these two economies, largely because more pigs and poultry were raised, requiring intensive grain feeding. The growth in demand for livestock products and for feedgrains in these economies is indicative of what is likely to happen in Third World countries that achieve rapid economic growth. In many of these countries, however, the increased demand for feedgrains might be met by increased domestic production.

For the 104 countries studied, imports of coarse grains increased from an average of 5 million metric tons during 1966-70 to about 16.5 million metric tons during 1976-80. The Food and Agriculture Organization of the United Nations estimates that more than three-quarters of the coarse grain imported by developing countries in 1981 were used for feed. Taking into account exports of coarse grains, the developing countries have gone from being net exporters of about 6 million metric tons of grain in the late 1960s to net importers of 3 million metric tons in the late 1970s.

As per capita incomes increase, the income elasticity of demand for cereals for direct consumption as food declines. The much higher income elasticity of demand for feedgrains may also decline but less rapidly. In some developing countries, such as Brazil, the amount of cereals used for feed already exceeds that used for food. As this trend becomes more widespread, the aggregate demand for cereals in developing countries will continue to increase, the decline in consumption as food being more than compensated for by the rise in feed use.

Alternative projections of the demand for cereal feed to 1990 and 2000 in the Third World in this study are based on past trends in cereal feed use and in livestock output. Five alternative methods result in projections ranging from 151 to 163 million metric tons of cereals used for feed in 1990 and from 245 to 286 million metric tons in 2000. The demand for cereal feed is projected to grow at rates varying from 4.7 to 5.5 percent per year to sustain an average growth in livestock products projected for 1980-2000 at about 3.7 percent.

Projections of the International Food Policy Research Institute (IFPRI) of the food deficit in the Third World, based on the continuation of past trends in production and per capita income, show that the developing countries (excluding China) would have an overall net food deficit of 76 million metric tons of basic food staples, including cereals and other major food crops, by the end of the century. This estimate is based on about 245 million metric tons of cereals used for feed in 2000, which is the lower level of demand projected in this report. If the higher level of demand should materialize, feed use could exceed that level by about 40 million metric tons, pushing the total food deficit to about 116 million metric tons, other assumptions remaining the same.

A recently completed IFPRI analysis of livestock products in the Third World also shows that if past income trends continue, trend projections of meat and milk output could fall considerably short of the projected demand at constant relative prices by the end of the century. The domestic output of meat and milk would have to increase 50 percent faster than past output trends to avoid significant pressure on prices or increases in imports. Under the alternative assumption of slower income growth, which is 25 percent less than trend growth, livestock production would still have to expand at rates higher than the 1961-77 trends to meet the projected demand. Thus, the derived demand for cereal feed could be even larger than projections based on trend estimates of output.

Because value added in the production, processing, and manufacture of meat, eggs, and dairy products is high, many of the developing countries may attempt to accelerate domestic production by introducing trade policies that favor imports of feedgrains rather than of meat and dairy products and by encouraging research and investment in intensive livestock production. Taste preferences for fresh meat, eggs, and milk over frozen or packaged meat, egg powder, or dry milk powder may reinforce such a policy. With economic growth and improved provision of refrigerated storage, transport, and marketing facilities, constraints on marketing and processing of perishable products may be eased, encouraging more rapid expansion in production and consumption of livestock products in the coming years. And because assured supply of livestock feed is an essential prerequisite for the development of livestock output, the use of cereals for feed would continue to grow rapidly.

Where gaps between the projected demand and supply of cereals used for feed cannot be met by imports, market forces could lead to higher meat and cereal prices,

which might worsen the food situation for the poor. Therefore, policies concerning cereals and livestock need to be reviewed and modified. For example, in countries with a surplus of rural labor a conscious decision should be made to adopt labor-intensive livestock production strategies to meet equity objectives: increased employment, improved nutrition, and food security for low-income people in developing countries. Improvements in the yields of feedgrains and in feed efficiency through emphasis on research and development of feed technology could also partly alleviate the situation. In addition, the scope for substituting noncereals, such as cassava supplemented with proteins, for cereals in compound and mixed feeds needs to be explored. Increased production of fodder also should be considered. However, as growing demand for feeds and fodder increase competition for land, it will have to be used more intensively. And large allocations of research resources will have to be made to development of new sources of feed, greater use of by-products and agricultural wastes, and of compound and mixed feeds.

A basic problem with the analysis of feed trends is the lack of reliable data on their use by type of feed and by category of livestock output. Developing countries should take steps for collection and publication of data on livestock feed and fodder, including data on compound and mixed feeds collected from existing feed manufacturing industries and data on cereals used directly as feed out of farmers' home-grown or purchased grains.

2

INTRODUCTION

A recent analysis of past trends in livestock products[1] in the developing countries shows that if these trends continue into the future, domestic demand for meat and milk could grow faster than indigenous production, leading to the emergence of large gaps between the two by the end of the century.[2] If the rapid income growth attained during 1966-77 continues, the consumption of meat may increase 5.0 percent a year, whereas milk consumption may rise 3.9 percent a year during the 1977-2000 period. Production is projected to grow by 3.4 percent a year for meat and 2.9 percent a year for milk during the same period. As a group, the 104 Third World countries included in the study, which had a surplus of 300,000 metric tons of meat in the mid-1970s, have already become net importers: by 1981 their net imports had risen to more than 1 million tons.[3] These countries imported nearly 9 million tons, net of exports, of milk and milk products in whole milk equivalents in the mid-1970s, and their net imports rose to about 16 million tons by 1981.[4] The deficits in these products could widen further by 2000, even if the rate of growth of output achieved during 1961-77 continued into the future. For eggs, the projected supply and demand would nearly balance, provided production by 2000 is three to four times the level attained in the mid-1970s. Even for meat and milk the projected outputs depend upon a twofold expansion of the levels of the mid-1970s. Even if per capita incomes increase less rapidly, that is, a quarter less than the 1966-77 rates, the projected shortfalls of meat and milk would still be large compared to the past, unless the output growth rate is accelerated.

Livestock is an important source of income and employment in the rural economy of Third World countries. It supplies essential inputs to crop production through the provision of draft power and manure for improving soil fertility. Development of livestock production can also help to meet the equity objective of rural development through the sector's contribution to cash incomes of small farmers, particularly in areas where a labor-intensive rural livestock development strategy is adopted. Increased income and employment are also realized through the value-adding industries associated with these products. Additional employment is generated by slaughterhouses, transport services, and the marketing of livestock products and feeds. Because livestock products contain high quality protein, their increased consumption could lead to improved nutrition in both urban and rural areas where protein intakes are particularly low. The livestock sector also contributes to foreign exchange earnings, especially in Latin America. For all of these reasons developing countries need to pay increasing attention to the development of the livestock sector in the coming decades. And, to sustain rapid growth in livestock production, large increases in livestock feed supplies will be essential.

Livestock feed is the most important input in livestock industry, no matter in what size farm or enterprise it is organized. Based

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[1] Hereafter in this report the term "livestock" includes poultry.

[2] J. S. Sarma and Patrick Yeung, *Livestock Products in the Third World: Past Trends and Projections to 1990 and 2000*, Research Report 49. Washington, D.C.: International Food Policy Research Institute, 1985.

[3] This study includes data for 104 countries referred to in this report as "the Third World countries." China and 24 very small developing countries are excluded. The term "developing countries," however, includes all of the developing economies.

All tons referred to in this report are metric tons.

[4] Imports of milk include those under food aid.

on the source of origin and end use, livestock feed may be classified into feedgrains, other staple crop feeds, high protein meals, agriculture and household by-products, and forage and fodder crops. Essentially, animals convert plant materials into edible products. Feeds provide the metabolic energy (in calories), proteins, and other nutrients, and these vary from feed to feed. Feed requirements can be differentiated according to the quantities needed for maintenance of the animals and those required for conversion into products. The standard requirements of different types of feed for different species of animals are usually drawn up in feed schedules designed to suit different environmental conditions for given levels of production. Such schedules, which often take into account the costs of feed and of output, are generally adopted by commercial or semicommercial farmers or government research stations and farms. But a majority of the rural smallholders and traditional graziers feed their livestock with locally available materials, including farm by-products, supplemented occasionally with concentrate feeds. These unbalanced and often inadequate diets, the traditional breeds of animals raised, and the prevalence of diseases explain the low productivity in output per animal on small farms in many developing countries.

Livestock feed can also be classified into the following groups: cereals; pulses; roots and tubers; oil seeds, cakes, and meals, and other protein meals including fish meal; molasses and other crop residues and agricultural and household by-products; cultivated fodder crops and grasses; pastures and other grasses; and agricultural wastes. The cereal feedgrains include coarse grains (such as maize, sorghum, millet, barley, oats, rye, and other cereals not elsewhere specified), wheat, and paddy (rice in husk), and their products and by-products. Cereal products are processed grains such as milled and broken rice and flours, and by-products are brans and cakes.

Feedgrains and roots and tubers provide a large share of the energy requirements of poultry and intensively fattened animals. Large ruminants such as cattle and small ruminants such as sheep and goats depend on forages and grass supplemented by feedgrains and protein meals for the bulk of their energy. Agricultural by-products such as straw and fodder stalks, which can be stored for the dry season, are also an important source of animal feed, particularly in developing countries. Feedgrains form 3.3 percent of the total estimated sources of livestock feed by weight and 16.6 percent in terms of energy in the world (Table 1).

The major difficulty in the analysis of past trends of livestock feeds is the nonavailability of reliable time-series data on their production and use in a number of developing countries. In many countries, separate annual data on grains used as feed are not systematically collected. Often such data are derived as a fixed percentage of production or supply, and hence the annual variations in feed use based on the published data for some countries do not reflect the true variations.[5] In countries where the commercial livestock sector is important, data on feed utilization are obtained and used to arrive at the total feed use for the year. The data used in this study are based on information obtained from the Food and Agriculture Organization of the United Nations.[6] (See Appendix 1 for additional discussion of the data and methods used.)

Another major difficulty is that information on feed use by species of livestock or type of livestock product is often not available. Apart from meat, milk, and eggs, draft power is one of the important uses of livestock in developing countries, but separate data on feed use by draft animals are not

[5] FAO's food balance sheets for 1975-77 specifically caution, "Since the quantities for feed and waste shown in the food balance sheets are often estimated from various sources, the percentage figures should be seen in conjunction with the balancing equation for the commodity in question in the food balance sheets and should not be judged on its own" (Food and Agriculture Organization of the United Nations, *Food Balance Sheets, 1975-77, Average and Per Caput Food Supplies* [Rome: FAO, 1980]).

[6] Food and Agriculture Organization of the United Nations, "Agricultural Supply/Utilization Accounts Tape, 1981" Rome, 1982.

Table 1—Estimated sources of livestock feed in the world

Feed	In Tonnage[a]	In Energy[b]
	(percent)	
Grain	3.3	16.6
Protein meal or cakes	0.5	2.3
By-products	1.7	6.2
Forages and others	94.5	74.9
Total	100.0	100.0

Source: R. O. Wheeler, et al., *The World Livestock Product, Feedstuff and Food Grain System* (Morrilton, Arkansas: Winrock International, 1981).

[a] Based on projected tonnage for 1985.

[b] Based on energy estimates for 1977/78.

collected.[7] Thus it is difficult to relate directly the feed use data with those for livestock output. As the grains produced within the country and those imported are both used as food and feed, it is difficult to build up a time series of production of feedgrains. Thus the trend analysis in this study is confined to feed use of grains only and not to their output. In view of the growing importance of feedgrains to sustain a rapidly growing livestock output in the coming years, the study attempts to analyze the available data despite these limitations.[8]

The analysis in this report covers the same 104 developing countries (excluding China) that are covered in *Livestock Products in the Third World.*[9] Of these, 21 are in Asia, 19 in North Africa/Middle East, 40 in Sub-Saharan Africa, and 24 in Latin America. Each of these regions is subdivided into two or three geographical subregions. For a classification of the countries, see Appendix 2, Table 20. China is excluded because no consistent and comparable time-series data on livestock products or feed use for mainland China, based on government series, are available.

The analysis of past trends is generally based on the averages for 1966-70 (the late 1960s) and 1976-80 (the late 1970s).[10]

Chapter 3 discusses the current situation for the use of cereal feed in 1980 and gives the corresponding figures on livestock numbers and output in 1980 to serve as background. Chapter 4 considers trends in aggregate cereal feed use and livestock output between the late 1960s and 1970s by regions and subregions and other typologies based on per capita income levels, per capita income growth, and growth in livestock output in the different countries. Chapter 5 examines developments in Taiwan and the Republic of Korea, where feed use has expanded rapidly in the last two decades.

As incomes rise beyond certain levels, per capita consumption of cereals directly as food declines and consumption of livestock products increases, resulting in increased derived demand for feedgrains. The dynamics of the combined use of cereals for food and feed are examined in Chapter 6, with illustrations from selected countries. Chapter 7 gives the main projections for feed use for 1990 and 2000 based on alternative methods and assumptions. The main conclusions of the study and their policy implications are given in Chapter 8.

[7] Moreover, in some developing countries a clear distinction is not maintained between animals used for draft power or for milk and those slaughtered for meat.

[8] This study is part of a series on past trends and projections prepared by the International Food Policy Research Institute, and its findings are derived in part from two earlier studies. See Leonardo Paulino, *Food in the Third World: Past Trends and Projections to 2000,* Research Report 52 (Washington, D.C.: International Food Policy Research Institute, 1986); and Sarma and Yeung, *Livestock Products in the Third World.*

[9] FAO publications do not give separate data for Taiwan but include them under China. Thus Taiwan is also not included in the 104 countries or in the Asia region. However, the case study on Taiwan discussed in Chapter 5 is based on data taken from Republic of China, Council for Agricultural Planning and Development, *Taiwan Food Balance Sheets, 1935-1980,* (Taiwan: Republic of China, 1981). These are not strictly comparable with FAO data and hence could not be combined with those for the 104 countries.

[10] Time series data on annual domestic utilization of cereals for food, feed, seed, and other uses were available from 1966 only.

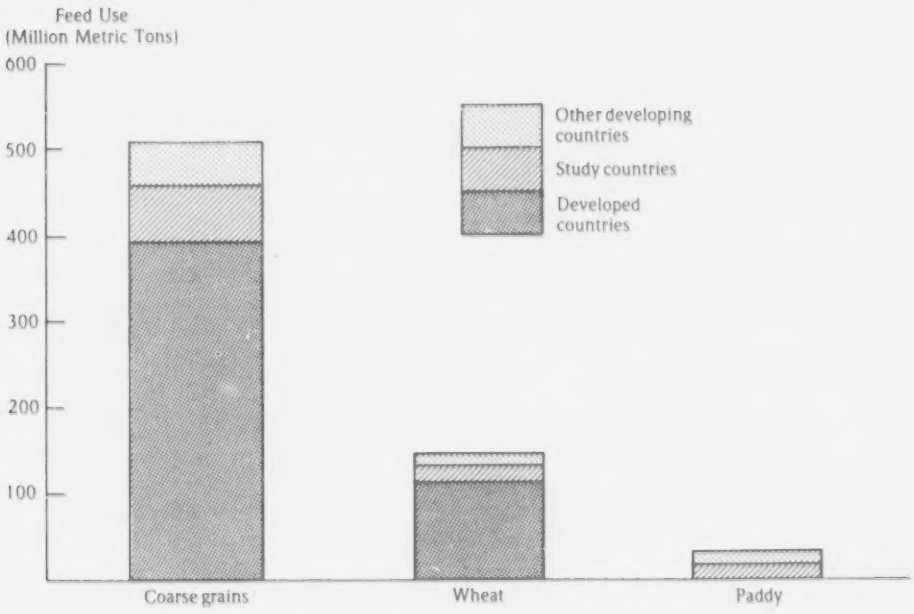
3

CEREAL FEED SITUATION IN 1980

About 680 million tons of cereals, including by-products, were used as livestock feed in the world in 1980. This constituted about 44 percent of the global cereal output (Appendix 3, Table 21). Among the cereals, coarse grains were the most important feedgrains, accounting for about three-fourths of the total. Wheat and its by-products were nearly one-fifth, the balance comprising paddy and its by-products (Figure 1). Seventy percent of world coarse grain production was used as feed, whereas only 8 percent of paddy and its by-products were fed to livestock. Nearly one-third of the global output of wheat (including by-products) was used as feed.

In the aggregate, developed countries used three times more grain to feed their livestock than the developing countries. About three-fourths of total cereal feed was used in the developed countries, which produced nearly two-thirds of the world's livestock output in 1980. Coarse grains—the major feedgrains—provided more than three-fourths of the total grains fed in the developed countries: about 82 percent of coarse grains produced was fed to livestock. Although coarse grains are also the pre-

Figure 1—World distribution of cereal feed use by crop, developed and developing countries, 1980



Source: Food and Agriculture Organization of the United Nations, "Agricultural Supply/Utilization Accounts Tape, 1981," Rome, 1982.
Note: Other developing countries include China and 24 small countries that are excluded from the study countries.

ferred feed in developing countries, about 46 percent of their domestic production is used as feed.

In 1980, about one-sixth of the cereals used as feed in the world was actually by-products, mostly bran. At 83 percent, the proportion of by-products was the highest for paddy. Only 5 percent of coarse grains fed was in the form of by-products; the proportion for wheat was about 37 percent. Again there were significant differences between the developed and developing countries in the use of by-products as feed—the respective shares being 9 percent in the former and 36 percent in the latter.

In the 104 study countries, about 100 million tons of cereal grains and by-products were fed to livestock in 1980—nearly 15 percent of the world feed use and 60 percent of their use in developing countries (including China). Of this quantity, two-thirds was coarse grain and the balance was divided almost equally between wheat and paddy (Table 2). Eighty-five percent of paddy, 77 percent of wheat, but only 10 percent of coarse grains were fed in the form of by-products. The share of by-products of wheat, paddy, and coarse grains in total feed use was a little more than one-third in the Third World countries in 1980. Feed use of cereals by type of product or by-product in 1980 is given in Appendix 3, Table 22.

As one would expect, Latin America, with its predominant share in the output of meat, milk, and eggs in the Third World, leads in the feed use of grains. All but one country (Haiti) in this region are in the middle- or high-income range. Meat is a staple food in some of these countries, especially Argentina and Uruguay. In 1980, about 43 million tons of cereals were fed to animals in this region. The share of coarse grains was nearly 86 percent. Asia followed with 30 million tons consumed as feed, but nearly half of this was in the form of paddy, rice bran, and other rice products and by-products. This is understandable because Asia produced 88 percent of the paddy in the study countries. Sub-Saharan Africa, which produced the smallest quantities of meat, milk, and eggs, also used the smallest amount of feedgrains, mainly coarse grains. More than two-thirds of the livestock feed in North Africa/Middle East was also in the form of coarse grains, particularly barley (9.2 million tons). About 14 million tons each of rice and wheat bran and other by-products were fed to animals in the four regions, taken together. Of the 65 million tons of coarse grains used as feed in the study countries, a little less than 57 percent was in Latin America, followed by about 24 percent in North Africa/Middle East.

Of the coarse grains, 39.1 million tons were maize, 10.4 million tons were barley, 11.7 million tons were sorghum, and the rest were other grains such as millets, oats, and rye. Sorghum was mainly used as feed in Latin America. In the case of wheat and its by-products, North Africa/Middle East is reported to have used about 40 percent of the Third World total for feeding its livestock. Two-thirds of this was wheat bran. About half a million tons of wheat bran were used as feed in Sub-Saharan Africa.

More than half of the cereal feed used in Latin America in 1980 was in the Upper South America subregion. In North Africa/Middle East, 70 percent was used in Western Asia; in Sub-Saharan Africa, nearly half was used in Eastern and Southern Africa; and in Asia, 57 percent was used in East and Southeast Asia.

As explained earlier, China is not covered by the analysis of past trends and projections because of a lack of adequate time-series data on feed use. According to recent FAO estimates, however, nearly 70 million tons of cereals were fed to livestock in China, including Taiwan, in 1980—slightly more than 10 percent of world cereal feed use. Coarse grains constituted 63 percent of the feed used in China.

Because the details of cereals fed to different species of livestock are not available, it is not possible to relate feed use to the number of animals in the different regions. However, Appendix 3, Table 23 shows that although nearly two-thirds of the world's large and small ruminants and 50-60 percent of pigs and poultry are in the developing economies (including China), they use only about a quarter of the cereal feed. This indicates a larger use of pastures and grazing

Table 2—Distribution of cereal feed use, by region, 1980

Region	Coarse Grains	Paddy	Wheat	Total	Share of By-Products (Including Bran)
			(million metric tons)		
Asia	9.4	15.0	5.7	30.2	20.6
North Africa/Middle East	15.5	0.3	7.2	23.0	5.4
Sub-Saharan Africa	3.2	0.3	0.5	4.0	2.5
Latin America	37.0	1.5	4.7	43.2	6.1
Total	65.1	17.1	18.1	100.3	34.6

Source: Food and Agriculture Organization of the United Nations, "Agricultural Supply/Utilization Accounts Tape, 1981," Rome, 1982.
Note: Parts may not add to total due to rounding.

lands as well as low-cost agricultural wastes and by-products for direct consumption as feeds in these countries.[11] Although at the regional level the proportion of ruminants, large and small, was higher in Asia than in Latin America, the proportion of feed use of cereals in the latter was higher, perhaps because Latin America has the largest number of pigs and poultry.

The developed economies, with almost one-quarter of the world population, produced nearly two-thirds of the meat, three-fourths of the milk, and three-fifths of the eggs in 1980, which shows the wide disparity in per capita production between the developed and developing economies. The 104 countries covered by this study shared roughly one-fifth of each of these products as compared to their share of 50 percent of global population in the same year. Among the regions, Latin America produced nearly half of the meat, one-third of the milk, and nearly two-fifths of the eggs in the Third World. Asia led in the production of milk with about 40 percent of the aggregate for the study countries. The output of all three products was extremely low in Sub-Saharan Africa, much lower than its 15 percent share of the population (see Table 3).

Table 3 also gives quantities of cereals fed to livestock in 1980. Because the weights of the three products are expressed in different terms, it would not be appropriate to add the output of each of the three products, ton for ton, and compare the total with the livestock feed use given in the table. Each of the outputs needs to be converted to a common denominator before they are aggregated to obtain the feeding ratio. Milk is the main problem because fresh milk contains 87-88 percent water. Often international trading is done in dry milk powder or in condensed and evaporated milk, which has a much lower percentage of water. One method of aggregation is to reduce milk to its dry weight by dividing by 10 (an average figure). The results are given in brackets below the fresh milk figures. When the weights of meat and eggs are added, the total is expressed as livestock output units (LOUs). In this method no correction factor is applied for meat or eggs, which also contain water.

Another method of aggregating the outputs would be to combine them on an energy basis because cereal feeds primarily provide energy to the animals. The energy content of various types of livestock products is expressed in physiological fuel values (PFVs).[12] The feeding ratio would represent

[11] Agricultural wastes and by-products are also used in the developed countries but mostly as ingredients of compound feeds.

[12] The individual PFVs expressed in 1,000 calories per kilogram of fresh product weight are: buffalo and cattle meat (carcass weight), 2.31; sheep and goat meat (carcass weight), 2.00; pigmeat, 4.20; poultry meat, 1.40; cow's milk, 0.62; buffalo milk, 1.00; sheep milk, 1.12; goat milk, 0.75; eggs, 1.50 (Winrock International, *Role of Ruminants in Support of Man* [Morrilton, Arkansas: Winrock International, 1981]).

Table 3—Output of meat, milk, and eggs in livestock output units and cereal feed use, 1980

Country Group/Region	Output				Cereal Feed Use	Feeding Ratio[b]
	Meat	Milk[a]	Eggs	Livestock Output Units		
	(million metric tons)					
World[c]	137.8	470.0 (47.0)	28.7	213.5	681.4	3.2
Developed economies	88.0	362.3 (36.2)	18.0	142.2	506.9	3.6
Developing economies (including China)	49.8	107.8 (10.8)	10.8	71.4	174.6	2.4
104 study countries (excluding China)[d]	27.0	99.3 (9.9)	5.3	42.2	100.3	2.4
Asia	5.8	43.8 (4.4)	1.6	11.8	30.2	2.6
North Africa/Middle East	3.5	16.4 (1.6)	0.8	6.0	23.0	3.8
Sub-Saharan Africa	3.5	5.9 (0.6)	0.5	4.5	4.0	0.9
Latin America	14.2	33.3 (3.3)	2.3	19.9	43.2	2.2

Sources: All figures are derived from data of the Food and Agriculture Organization of the United Nations (FAO). World data are from FAO, *Production Yearbook 1982* (Rome: FAO, 1983); country data are from FAO, "Production Yearbook Tape, 1981," Rome, 1982; and the cereal feed use data are from FAO, "Agricultural Supply/Utilization Accounts Tape, 1981," Rome, 1982.

Notes: In this table, the output of meat is expressed in carcass weight, milk in whole fresh milk equivalents, and eggs in fresh weight. Livestock output units are weights of meat, milk, and eggs converted to a common denominator to obtain a total for livestock products. Milk is reduced to its dry weight by dividing by 10; then weights of meat and eggs are added. Meat includes beef, veal, buffalo meat, mutton and goat meat, pig and poultry meat; and milk includes cow, buffalo, sheep, and goat milk; eggs include hen eggs and other eggs. Parts may not add to total due to rounding.

[a] The figures in parentheses refer to dry milk equivalents.

[b] Feeding ratio is the average quantity of cereals and by-products used to produce one unit of livestock products.

[c] These countries are grouped according to the classification system of the Food and Agriculture Organization of the United Nations.

[d] These countries are grouped according to the classification system of the International Food Policy Research Institute.

the cereal feed use per unit of PFV.

Whereas there would be no difficulty in using PFVs by type of meat and milk in the analysis of past trends of specific commodities, using individual energy values to obtain the aggregate of livestock products is difficult, particularly when output projections for the future are based on the aggregates for meat and milk, and not by the types of meat and milk. For cereal feeds, although the energy content of each cereal grain is different, the quantities of all the grains are aggregated ton for ton. It is also possible to convert the cereals into energy equivalents and to work out a ratio of the energy equivalents of cereal feeds and livestock outputs, but as a feeding ratio this coefficient has limited use.

Another method takes into consideration the input/output ratios of each of the livestock products. But these vary considerably from country to country and over time for the same species of livestock depending upon the composition of the feed, techniques

of production, and so forth. In general the input/output ratio for milk varies from 0.3 to 0.4:1. For meat, it varies widely between types. For example, the ratio is 2 to 3:1 for intensively fed chicken meat, 4 to 6:1 for intensively fed pigmeat; and even higher for intensively fed beef. For traditionally raised, home-produced livestock products the ratios are much lower. On average, the feeding ratio may be taken to be around 3 to 4:1 for meat and eggs. In other words, the grain feed required to produce one unit of fresh milk is about one-tenth of that required for meat or eggs. This also suggests that dividing the milk output by 10 for converting into LOUs is reasonable, though this understates the importance of milk from a nutritive point of view, but not from a feed use point of view.

Although this method of dividing milk output by 10 and adding it to the output of meat and eggs is somewhat rough, it seems to be a better indicator of total livestock production than the one obtained by adding meat, milk, and eggs ton for ton for the limited purpose of working out the feeding ratios. Thus, the output of meat, milk, and eggs is converted into LOUs in Table 3.

The total cereal feed use in the different regions still cannot be compared with the total output of livestock products because the feed data include quantities fed to draft animals and those fed to other animals such as young calves and cows not in milk, for which no separate data are available. In interpreting the data on cereal feed use and livestock output in the different regions in Table 3, these limitations must be kept in mind. It will be seen that the average ratio of feed used for one unit of livestock output—the feeding ratio—comes to 2.4 in 1980 for the study countries as a whole.

Despite the limitations of the data, they show that the feeding ratio in developing countries is about two-thirds of that for developed countries. The lower ratio in developing countries suggests that they rely more on nongrain feeds, such as pasture, straw, and agricultural wastes for feeding cattle, which, though cheaper, reduce the output per animal. Among the study countries, the ratio is high in North Africa/Middle East and low in Sub-Saharan Africa. The composition of meat by type and the livestock production technology and feeding practices adopted also partly explain the regional differences in the ratios.[13]

To the extent that improved livestock production technologies are more feed-intensive, these technologies increase the demand for feedgrains. Thus, in areas where poultry, pig, and dairy production have expanded through commercial or semicommercial enterprises, the manufactured feed industry has also developed, thereby increasing the demand for cereal feeds. This increased demand has been met by imports where domestic production is inadequate.

[13] A disaggregated analysis of meats by type would have thrown more light on the variation in the ratios, but data on feed use by type of meat are not available.

4

TRENDS IN CEREAL FEED USE

Use of cereals for feed in the Third World countries increased faster than the output of meat and milk. The quantity of cereal grains and by-products fed to livestock rose from 57 million tons a year in 1966-70 to 90 million tons in 1976-80, an average rate of 4.6 percent a year (see Appendix 3, Table 24 and Figure 2).

Among the developing regions, Latin America is a major livestock producer, and this is reflected in the amount of cereals used for feed. In the late 1970s, this region held a 42 percent share of total feed use in the Third World, and it also accounted for 44 percent of the increase between the two periods (Table 4). The 5 percent-a-year rate of growth in feed use in this region is thus a little higher than the average growth rate for the 104 study countries taken together. In North Africa/Middle East, feed use increased from 12.5 million tons in the late 1960s to 20.5 million tons in the late 1970s. At 3.1 percent a year, growth of feed use in Sub-Saharan Africa was the lowest among the four developing regions; this seems consistent with the relatively slow growth rate for output of livestock products in this region. In Asia, which used about 31 percent of total feed, growth in the use of cereal for feed was less than the average for Third World countries, largely because of the slower growth in South Asia and in the use of by-products such as rice bran for feed.

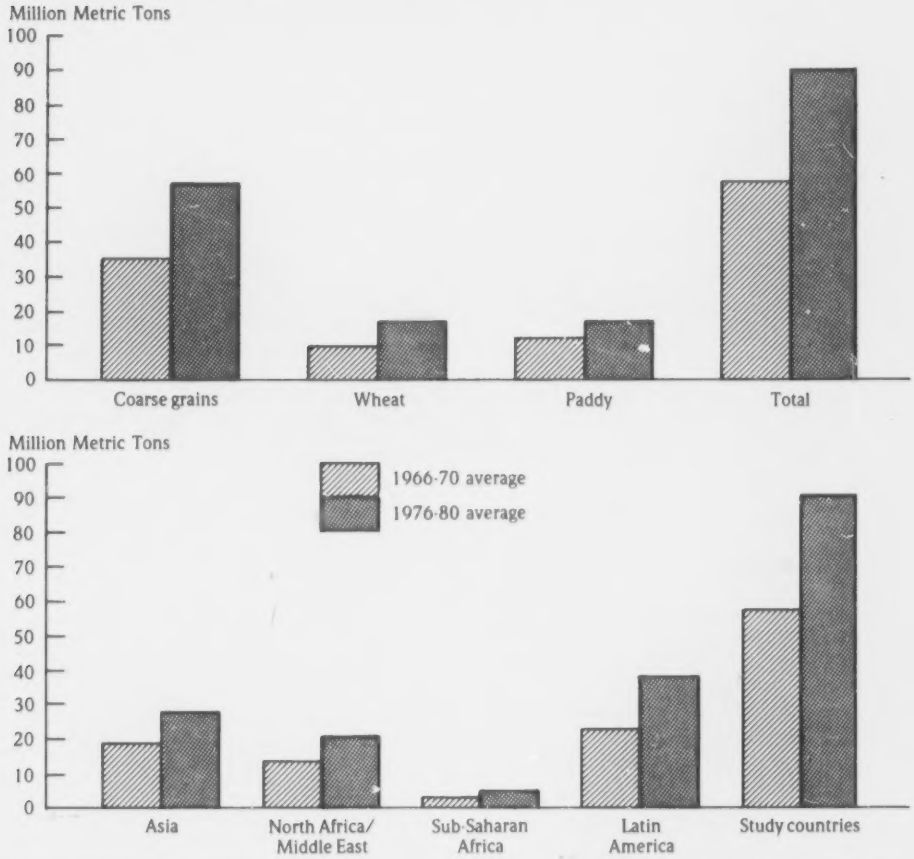
Reaching 56.6 million tons in the late 1970s, feed use of coarse grains increased at a rate slightly faster than that of total cereal feeds between 1966-70 and 1976-80. The growth rates were even higher in Asia and Latin America. Quantities of wheat and paddy used as feed were nearly the same at 17 million tons each in the late 1970s, but the growth in the use of wheat at 5.5 percent was much higher than the 3.0 percent in paddy. Seventy-five percent of the wheat fed was in the form of bran. Consumption of wheat bran increased from 7.5 million tons in 1966-70 to 12.5 million tons in 1976-80, an average annual increase of 5.3 percent. Nearly 90 percent of the paddy fed was in Asia. Again, 85 percent of total paddy feed was in the form of rice bran and cakes in 1976-80, and use of these by-products rose more slowly at 2.8 percent a year. In the case of coarse grains, bran and cakes formed only about 10.5 percent of feed use in the late 1970s, which is less than their 13.6 percent share in the late 1960s.

Among the coarse grains, maize was the preferred feedgrain in Latin America and Asia. In North Africa/Middle East, barley was more important than maize, although maize's share was increasing. In Latin America, maize accounted for three-fourths of the coarse grain fed in the late 1960s. This share declined to about two-thirds in the late 1970s, when about 21.3 million tons of maize were used as feed. The use of sorghum for feed in Latin America increased relative to maize. In Asia, maize's share of coarse grains increased from about 60 percent to nearly 75 percent, largely from imported maize. In North Africa/Middle East in the late 1970s, 8.2 million tons of barley and 3.5 million tons of maize were utilized out of a total cereal feed use of 20.4 million tons. The corresponding figures for the late 1960s were 5.3 million tons of barley and 1.4 million tons of maize out of a total feed use of 12.5 million tons.

Use of Cereal Grains and By-Products

The growth rates and importance of whole grains and by-products varied between regions and commodities. In the aggregate, nearly 64 percent of the cereal feed used in the late 1970s was in the form of

Figure 2—Trends in feed use of cereals in the study countries, by crop and region, 1966-70 and 1976-80



Source: Food and Agriculture Organization of the United Nations, "Agricultural Supply Utilization Accounts Tape, 1981," Rome, 1982.

grains (including grain products) and 36 percent was in by-products, mainly bran and cakes. In the late 1960s grains were 60 percent and by-products 40 percent.

Thus cereal feeds, excluding by-products, increased from about 34 million tons in the late 1960s to 57 million tons in the late 1970s, a growth rate of 5.3 percent a year, which is higher than 4.6 percent for total cereal feed (Table 5 and Appendix 3, Table 25). Latin America held a 56 percent share of this feed use in the late 1970s. Asia exhibited the most rapid growth at 6.3 percent a year. Coarse grains constituted 88 percent of the total in the late 1970s. The use of wheat and wheat flour, however, rose most rapidly at about 6 percent a year, while paddy use increased by 4 percent a year.

Of the total of 33 million tons of cereal by-products, mainly bran, used as livestock feed, rice and wheat held shares of 43 and 38 percent, respectively, in the late 1970s. The coarse grains were fed largely as grains, and their by-products constituted about one-

Table 4—Distribution of cereal feed use by region and commodity, 1976-80 average

Region	Regional Distribution				Commodity Distribution			
	Coarse Grains	Wheat	Paddy	Total	Coarse Grains	Wheat	Paddy	Total
	(percent)							
Asia	15	31	89	31	30	18	52	100
North Africa/Middle East	24	40	2	23	66	32	2	100
Sub-Saharan Africa	5	3	2	4	81	12	7	100
Latin America	56	27	8	42	85	12	3	100
Total	100	100	100	100	63	19	18	100

Source: Food and Agriculture Organization of the United Nations, "Agricultural Supply/Utilization Accounts Tape, 1981," Rome, 1982.
Note: Parts may not add to total due to rounding.

tenth of the total. Asia used most of the rice bran—about 12.6 million tons out of 14.2 million tons of feed. Wheat bran feed use was distributed more evenly among the three developing regions of Asia, North Africa/Middle East, and Latin America (Appendix 3, Table 25).

Because brans are by-products, growth in their use as feeds depends in part on growth in output of the grains from which they are derived. For example, paddy output in the developing countries increased 2.8 percent a year between the late 1960s and 1970s, which is the same as the growth rate in the use of rice bran as feed during the period. On the other hand, wheat bran use increased by 5.3 percent a year, which was higher than the 4.8 percent-a-year growth in the output of wheat in Third World countries. This is largely because of the increase in net imports of wheat into these countries, either through trade or food aid. It is significant that rice is traded in its milled form, whereas wheat is mostly traded as whole grain. Thus rice bran is available for use in the exporting countries, while wheat bran is more likely to be used in the importing countries. These differences are evident in Table 6, which shows the annual growth rates in the use of wheat and rice brans as feed and the corresponding growth rates in the output of wheat and paddy during the two periods.

In Asia, however, the use of wheat bran as feed grew more slowly than the output of the whole grains, especially in South Asia. Including the use of bran from coarse grains, the use of total cereal by-products increased 3.6 percent during the period, compared to 4.6 percent for all cereal feeds. Moreover, because growth in the use of rice bran was constrained by growth in the output of paddy, any further acceleration in the overall use of cereal feed, particularly in Asia, would have to come from growth in feeds other than rice bran.

Table 5—Trends in the feed use of grains, by region and commodity, 1966-70 and 1976-80

Region/Commodity	Grains Used for Feed		
	1966-70	1976-80	Growth Rate
	(million metric tons)		(percent)
Asia	4.54	8.35	6.3
North Africa/Middle East	9.41	15.61	5.2
Sub-Saharan Africa	0.98	1.40	3.6
Latin America	19.29	31.99	5.2
Total	34.21	57.35	5.3
Coarse grains	30.22	50.68	5.3
Wheat	2.37	4.26	6.0
Paddy	1.62	2.41	4.0

Source: Food and Agriculture Organization of the United Nations, "Agricultural Supply/Utilization Accounts Tape, 1981," Rome, 1982.
Note: Parts may not add to total due to rounding.

Table 6—Annual growth rates of use of brans as feed and output of cereals, by region, 1966-70 and 1976-80

Region	Rate of Growth			
	Wheat Bran Feed	Wheat Output	Rice Bran Feed	Paddy Output
	(percent/year)			
Asia	5.9	6.7	2.8	2.8
North Africa/ Middle East	5.5	3.7	−0.4	0.8
Sub-Saharan Africa	6.3	0.7	3.1	2.9
Latin America	4.1	2.8	3.9	3.7
Total	5.3	4.8	2.8	2.8

Source: Food and Agriculture Organization of the United Nations, "Production Yearbook Tape, 1981," Rome, 1982; and Food and Agriculture Organization of the United Nations, "Agricultural Supply/Utilization Accounts Tape, 1981," Rome, 1982.

Trends in Output Growth of Livestock Products

When the production of meat, milk, and eggs in each country was converted into LOUs, an average growth rate of 3.4 percent was recorded between the periods 1966-70 and 1976-80. Meat output grew 3.1 percent; milk, 3.0 percent; and eggs, 5.7 percent at annual compound rates. The output of these products increased from 28.3 million tons in the late 1960s to 39.4 million tons in the late 1970s (Table 7 and Appendix 3, Table 26). Less than half of the output during the latter period was from Latin America, although its share of the population was only one-sixth. Asia, with its 58 percent population share, produced only 28 percent of Third World output. Except in Sub-Saharan Africa, where output growth was about 2.2 percent, output in the other three regions grew about 3.5 percent a year.

The annual growth rate in cereal feed use in developing countries outstripped that of the output of livestock products by more than 1.2 percent a year (see Figure 3). In Latin America, feed use growth was 1.5 percent ahead of livestock output growth. The difference between the two growth rates was smallest in Asia, where feed use increased at 4.2 percent a year. These differences are more marked at the subregional level.

Subregional and Selected Country Trends

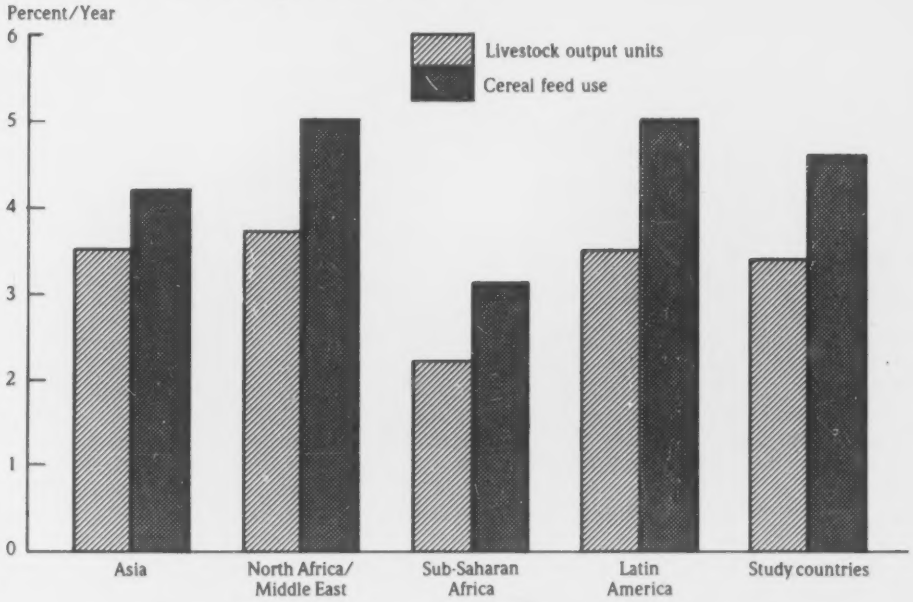
Countries of the Upper South America subregion, which is largely in the tropics, accounted for a little more than half of the cereal feed use in Latin America, as well as a little less than half of the region's livestock output in the late 1970s. The most rapid growth in cereal feed use, however, was in the Central American subregion, which includes Mexico and the Caribbean countries. There livestock feed more than doubled,

Table 7—Regional distribution and trends of output of livestock products, 1966-70 and 1976-80, and distribution of population, 1980

Region	Output in Livestock Output Units			
	1966-70	1976-80	Annual Average Growth Rate	1980 Population
	(million metric tons)		(percent)	
Asia	7.73	10.94	3.5	58.2
North Africa/Middle East	3.88	5.58	3.7	11.2
Sub-Saharan Africa	3.42	4.24	2.2	14.9
Latin America	13.24	18.59	3.5	15.7
Total	28.27	39.35	3.4	100.0

Source: Food and Agriculture Organization of the United Nations, "Production Yearbook Tape, 1981," Rome, 1982; and United Nations, Department of International Economic and Social Affairs, "World Population Prospects as Assessed in 1982," New York, 1983 (computer printout).

Figure 3—Growth rates of cereal feed use and livestock products output, by region, 1966-70 and 1976-80



Sources: Food and Agriculture Organization of the United Nations, "Production Yearbook Tape, 1981," Rome, 1982; and Food and Agriculture Organization of the United Nations, "Agricultural Supply/Utilization Accounts Tape, 1981," Rome, 1982.
Note: Livestock products are expressed in livestock output units derived as meat + 1/10 milk + eggs.

rising from 5.1 million tons in the late 1960s to 10.4 million tons in the late 1970s (see Appendix 3, Table 26). In comparison, livestock output in this subregion increased only about 60 percent. In temperate Lower South America, growth rates in the use of feed and in livestock output were low during this period—1.5 percent and 1.4 percent. This subregion held a one-fifth share of Latin America's feed use but nearly 30 percent of its livestock output in the late 1970s. Cereal feed use in Latin America was highest in Brazil—15.3 million tons a year on average during 1976-80 compared to 9.6 million tons during 1966-70. In Mexico, feed use doubled from 4.0 million to 8.1 million tons during the same period. Argentina showed a slower growth rate of about 1.5 percent a year, rising from 5.4 million tons to 6.3 million tons during this period.

Of the 28.3 million tons of feed used in Asia in the late 1970s, South Asia accounted for about 13.3 million tons or less than half, whereas this subregion produced about 55 percent of the livestock output. The East and Southeast Asia subregion, which comprised several newly industrializing countries with relatively rapid growth in income, used more than half of Asia's feed. This was more than 70 percent higher than in the late 1960s. The growth rate of feed use was 1.3 percent higher than that of livestock output in this subregion, and nearly double that of South Asia. The Republic of Korea recorded a 13.5 percent yearly increase in feed use. It rose from about 800,000 tons in the late 1960s to 2.8 million tons in the late 1970s. Cereal feed use in India was estimated at about 10 million tons in the late 1970s, although this represented an

increase of only 2.8 percent a year compared to the late 1960s. Hong Kong, Indonesia, Malaysia, Mongolia, the Philippines, and Singapore all recorded growth rates of 5 percent or more.

In North Africa/Middle East, Turkey used the largest amount of cereal feed—8.3 million tons in the late 1970s, mostly coarse grains. Turkey's rate of growth in feed use, however, was only 3.2 percent a year. The Western Asia subregion, which included Turkey, had a 70 percent share of the region's feed use and a 65 percent share of livestock output. The growth rate for feed in this subregion was two-thirds that in the Northern Africa subregion. A number of countries in the latter subregion exhibited growth rates exceeding 5 percent a year, including Algeria, Egypt, Libya, Morocco, Sudan, and Tunisia. Feed use in Saudi Arabia increased rapidly, by 29 percent a year, increasing from 42,000 tons in the late 1960s to more than half a million tons in the late 1970s. In many of these countries, rapid growth in per capita incomes through oil revenues resulted in larger demand for livestock products, part of which was met from increased domestic production.

In the late 1970s, more than half of the cereal feed use in Sub-Saharan Africa was in the Eastern and Southern Africa subregion. Central Africa's share was less than 10 percent. These shares are similar to their shares of livestock output. The growth rate for feed use in Eastern and Southern Africa was about 3.0 percent a year, and that for Central Africa was 4.3 percent. In West Africa, feed use increased by 3.1 percent a year. Nigeria used roughly 578,000 tons of cereal feed in the late 1970s, which accounted for about 40 percent of West Africa's feed utilization, as compared to its share of 48 percent of livestock output.

Feed Use by Per Capita Income, Income Growth, and Livestock Output Growth

The utilization of cereals as livestock feed is high in high-income countries. To study this relationship, the countries were classified into four groups: those with a per capita income at 1980 prices of less than $250, $250-499, $500-1,999, and more than $2,000 per year in 1980. Cereal feed use was then aggregated for each group of countries. Feed data were also grouped by two other criteria: per capita income growth during 1961-80 (less than 1.0 percent, 1.0 to 2.9 percent, 3.0 to 4.9 percent, and 5.0 percent and more per year) and by rate of growth in livestock products (less than 1.0 percent, 1.0 to 2.9 percent, 3.0 to 4.9 percent, and 5.0 percent and more) between 1966-70 and 1976-80. The relevant data are given in Table 8.

Of the 104 developing countries included in the study, 20 high-income countries, with average per capita incomes exceeding $2,000 a year, used nearly 43 percent of the feed consumed in developing countries in the late 1970s; this is about the same as their share of livestock output. These countries accounted for only 15 percent of the Third World population. At the other end of the scale, 19 very-low-income countries accounted for about 44 percent of the total population, but their share of feed use was less than one-sixth, and they contributed 18 percent of the total livestock output. The growth rate of feed use in these countries was also low—a little more than half of the growth rate for the developing countries as a whole.

When the countries were grouped according to per capita income growth, countries with medium growth had a 36 percent share of feed use and those with rapid growth, a 27 percent share in the late 1970s. Their respective shares of livestock output were 27 and 21 percent. The growth in feed use in the rapid-income growth countries was a little less than 6 percent a year, which is about 30 percent higher than the overall growth rate. In 27 countries, with one-sixth of the total population, per capita incomes rose less than 1 percent. These countries used only about 8 percent of the total cereal feed and produced only 13 percent of livestock products in the late 1970s.

Finally, the countries were grouped

Table 8—Cereal feed use, classified by level and growth of per capita income and growth of livestock output, 1966-70 and 1976-80

Country Group	Number of Countries	Percent of Population in 1980	1966-70 Livestock Output Unit	1966-70 Feed	1976-80 Livestock Output Unit	1976-80 Feed	Growth Rate 1966-70 to 1976-80 Livestock Output Unit	Growth Rate 1966-70 to 1976-80 Feed
			(million metric tons)				(percent)	
Level of per capita income, 1980								
Less than $250	19	44	5.65	11.70	7.12	14.94	2.3	2.5
$250–$499	19	16	2.99	3.32	4.08	5.24	3.2	4.7
$500–$1,999	46	25	8.07	18.38	11.70	30.86	3.8	5.3
$2,000 or more	20	15	11.57	23.82	16.45	38.99	3.6	5.1
Total	104	100	28.27	57.21	39.35	90.03	3.4	4.6
Growth rate of per capita income, 1961-80								
Less than 1 percent	27	16	3.97	5.91	5.07	7.45	2.5	2.3
1 percent–2.9 percent	36	48	11.89	18.63	15.23	25.84	2.5	3.3
3 percent–4.9 percent	23	25	7.19	19.23	10.61	32.86	4.0	5.5
5 percent or more	18	11	5.22	13.44	8.45	23.88	4.9	5.9
Total	104	100	28.27	57.21	39.35	90.03	3.4	4.6
Growth rate of livestock output, 1961-80								
Less than 1 percent	13	5	2.14	1.73	2.13	1.88	. . .	0.8
1 percent–2.9 percent	23	15	7.37	11.71	8.82	16.00	1.8	3.2
3 percent–4.9 percent	44	62	14.51	32.74	20.83	48.89	3.7	4.1
5 percent or more	24	18	4.26	11.02	7.58	23.26	5.9	7.7
Total	104	100	28.27	57.21	39.35	90.03	3.4	4.6

Source: Food and Agriculture Organization of the United Nations, "Agricultural Supply/Utilization Accounts Tape, 1981," Rome, 1982; Food and Agriculture Organization of the United Nations, "Production Yearbook Tape, 1981," Rome, 1982; and World Bank, "Gross National Product by Country Data Tape, 1961-80," Washington, D.C., 1981.

Notes: Parts may not add to total due to rounding. Livestock output unit (LOU) = meat + 1/10 milk + eggs.

according to the rates of growth of their livestock output. Between the late 1960s and late 1970s livestock output increased between 3 and 5 percent a year in 44 countries with a combined population share of 62 percent. In another 24 countries with a population share of 18 percent, the rate of growth exceeded 5 percent per year. The former group of countries had more than a 54 percent share of feed use, whereas the latter group accounted for about 26 percent. Between them their share of feed use was a little more than 80 percent. These countries accounted for 72 percent of livestock output and 80 percent of population. Countries where the output of livestock rose more than 5 percent a year recorded a growth of about 8 percent per year in feed use.

This analysis indicates that in the past the share held by high-income countries in total livestock output was high; consequently, their share of feed use also was high. Many of these countries, particularly in East and Southeast Asia, had poor grazing lands and relied more on poultry and pigs for increased domestic meat production. This also contributed to the rapid growth in the use of cereal feeds.

Trends in Food and Feed Use of Cereals

A recent IFPRI study of the utilization of cereals for food and feed shows that between 1966-70 and 1976-80, feed use increased

more rapidly than direct consumption as food. For the Third World countries as a whole, livestock feed use rose 4.6 percent, whereas food use increased at an average rate of 3.1 percent per year (Table 9). Meanwhile, population grew 2.5 percent and livestock output 3.4 percent a year. In Latin America, feed use rose almost one-and-a-half times as fast as direct consumption of food. In the three other regions as well, feed use rose faster than food.

Consumption of livestock products rose faster than that of cereal foods, and, as a result, the derived demand for cereals for feed increased more rapidly than direct food demand. This is discussed in more detail in Chapter 6.

Table 9—Rate of growth of use of cereals for food and feed, by region, 1966-70 and 1976-80

Region	Food Use	Feed Use
	(percent/year)	
Asia	3.0	4.2
North Africa/Middle East	3.6	5.0
Sub-Saharan Africa	2.6	3.1
Latin America	3.3	5.0
Total	3.1	4.6

Source: Food and Agriculture Organization of the United Nations, "Agricultural Supply/Utilization Accounts Tape, 1981," Rome, 1982.

Imports of Coarse Grains

Some developing countries met their increased demand for feedgrains, largely coarse grains, through imports. For the 104 study countries taken together cereal imports increased from an average of 4.9 million tons during 1966-70 to 16.5 million tons during 1976-80 (Table 10). Although part of these imports must have been for direct food use, FAO estimates that animal feed accounted for more than three-quarters of developing-country imports of coarse grains in 1981.[14] Among the major net importers of coarse grains for feed were the Republic of Korea, Malaysia, Iran, Egypt, Saudi Arabia, Cuba, Mexico, Brazil, and Venezuela, each of which had net imports of more than half a million tons on average during the 1976-80 period. The 104 study countries taken together, which had net exports of coarse grains of about 5.8 million tons in the late 1960s, became net importers of 3.2 million tons in the late 1970s.

Table 10—Exports, imports, and net trade in coarse grains, 1966-70 and 1976-80 averages

Region	1966-70 Average			1976-80 Average		
	Exports	Imports	Net Trade	Exports	Imports	Net Trade
	(million metric tons)					
Asia	1.86	2.08	−0.22	2.76	4.05	−1.29
North Africa/Middle East	0.42	0.80	−0.38	0.34	3.95	−3.61
Sub-Saharan Africa	0.85	0.71	0.14	0.52	1.69	−1.17
Latin America	7.59	1.29	6.29	9.67	6.80	2.87
Total	10.71	4.87	5.83	13.28	16.49	−3.21

Source: Food and Agriculture Organization of the United Nations, "Agricultural Supply/Utilization Accounts Tape, 1981," Rome, 1982.
Note: A minus sign indicates net imports.

[14] Food and Agriculture Organization of the United Nations, *Livestock Development in Developing Countries and Implications for Consumption and Trade of Feeds* (CCP: GR 82/83), 1983.

Meat/Feed Price Ratios

When world food prices are high, as in the early 1970s, the feeding of cereals to livestock is reduced in the developed countries, and the grains released become available for food use. When prices are low, larger proportions of cereals, particularly coarse grains, are diverted to feed use. Although in the short run, "livestock in fact provided a cushion that served to dampen world market shocks by 'stretching' the grains that were diverted from indirect to direct use," the long-term consequences of food-feed competition are more complex.[15] For a systematic study of the relationship between the prices of cereal feed and the demand for it, several other factors, such as prices of different components of feed and of different types of livestock output, feed efficiency, and price regulations if any on feed ingredients and livestock products, would have to be considered. This is beyond the scope of the present study. However, to give a broad picture of the price trends in feed, annual ratios of producer prices of poultry meat/maize and of pigmeat/maize were worked out for the period 1967-80 for selected countries and are presented in Table 11. This ratio indicates the units of maize that could be purchased in exchange for one unit of meat. Where ratios are high or increasing, livestock production becomes more profitable, leading to increased feed use and vice versa.

The actual data given in the tables do not, however, show any uniform and consistent trends among the selected developing countries, except that, as mentioned earlier, when world food prices were high in the years 1973-75, the meat/feed price ratios were mostly low. In Brazil and Kenya, the ratios were generally falling during the 1967-80 period. On the other hand, in Turkey, Egypt, and India the ratios were rising. In other countries, the behavior was mixed.

Manufactured Feed

The increased demand for livestock products in some developing countries was met through livestock, poultry, and dairy enterprises organized on commercial or semicommercial lines, while in others increased production was sought through small-scale rural enterprises, developed on a cooperative or other basis. In either case, these efforts were supported by feeds, either compound or mixed, largely manufactured in the private sector. The available data indicate rapid growth in the output of these industries. According to information collected by FAO from national governments and feed and feed-ingredient associations, the production of compound feeds in developing countries (excluding China) doubled over a period of five years from an average of about 20 million tons during 1974-76 to 40 million tons in 1980. Latin America produced more than half of the 1980 output, 21.6 million tons. Brazil alone produced 11.4 million tons of compound feed in 1980. Available data for selected developing countries for the years 1974-76 (average) and 1980 are given in Appendix 3, Table 27.

Detailed data on the composition of these feeds are not available, but cereals constituted an important ingredient, although the proportion of cereals varied from type to type. This increase in the output of manufactured feed also contributed to the rapid growth in cereal feed use. These trends are likely to continue into the future.

[15] The linkage of the two markets, grains for direct consumption and those for animal feed, and the policy implications of the food-feed competition are discussed in Pan A. Yotopoulos, "Middle Income Classes and Food Crisis: The 'New' Food-Feed Competition." *Economic Development and Cultural Change* 33 (No. 3, 1985): 463-483.

Table 11—Ratios of prices received by farmers for poultry and pigmeat to maize, selected countries, 1967-80

Ratio/Country	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Poultry meat/maize price ratio														
Argentina	9.50	10.80	8.90	9.50	12.18	7.70	8.14	10.12	19.48	13.03	12.83	11.96	16.29	14.14
Brazil	15.27	15.28	14.02	14.92	15.00	13.31	15.59	12.97	12.41	11.27	12.39	10.27	11.18	9.18
Egypt	11.26	14.59	13.33	13.37	13.32	13.40	12.36	12.95	13.39	15.53	14.89	17.69	18.39	11.64
India	5.97	7.34	6.84	8.13	7.92	6.85	6.70	5.64	6.97	10.24	8.78	9.67	10.45	10.86
Indonesia	34.76	23.66	12.99	13.66	17.91	17.54	20.64	20.55	17.08	13.71	20.98	27.94	19.81	18.70
Kenya	12.67	14.53	16.25	19.87	16.70	14.29	14.99	14.81	11.76	12.22	11.72	15.10	13.38	13.78
Korea, Republic of	16.75	16.68	15.86	17.78	16.84	12.86	12.74	12.67	14.71	17.49	17.76	18.68	15.56	11.29
Mexico	12.45	12.80	13.15	12.89	12.89	13.06	11.53	9.93	8.60	8.29	10.80	9.27	9.35	7.57
Nigeria	17.55	17.39	17.50	17.50	17.47	17.53	17.56	17.50	16.61	15.31	15.31	15.31	11.45	13.45
Philippines	10.24	11.12	10.76	9.44	8.70	8.22	8.65	8.74	8.67	8.75	9.78	10.52	13.40	13.34
Thailand	11.56	18.92	17.61	15.19	20.08	14.30	10.74	9.11	10.46	11.66	12.39	12.83	10.56	11.10
Turkey*	13.73	14.46	14.21	14.81	19.73	22.03	18.31	13.10	13.03	16.17	18.18	23.17	43.60	38.86
Pigmeat/maize price ratio														
Argentina	8.11	12.29	10.76	9.45	11.34	10.91	10.10	12.52	12.61	11.72	12.25	13.62	14.79	10.99
Brazil	6.09	6.05	5.60	5.88	6.35	5.54	6.75	5.06	5.23	4.54	5.11	4.45	5.48	4.74
India	4.57	5.80	5.34	6.27	6.31	5.34	4.70	3.81	4.71	6.91	5.93	6.53	7.06	7.33
Indonesia	10.27	4.58	5.45	5.57	5.33	5.06	6.05	6.01	12.89	14.52	21.43	29.41	20.86	19.68
Korea, Republic of	7.33	9.82	8.42	9.96	10.47	7.59	9.16	7.32	9.01	10.88	9.79	13.52	9.78	8.87
Mexico	9.66	9.95	11.81	12.22	12.33	13.44	12.97	12.67	10.19	9.19	10.08	10.30	11.33	9.05
Nigeria	11.84	11.74	11.83	11.76	11.72	11.72	11.78	11.76	11.22	10.31	10.31	10.31	7.70	9.05
Philippines	7.55	7.76	6.89	7.44	7.28	6.42	6.24	6.11	5.66	5.46	8.89	10.56	10.43	10.51
Thailand	9.59	17.28	16.77	11.71	13.49	11.08	8.46	9.05	10.58	10.87	12.83	11.16	10.52	11.60

Source: Food and Agriculture Organization of the United Nations, "Producer Prices Tape, 1985," Rome, 1985.
* For Turkey, barley prices were used instead of maize prices.

5

GROWTH IN CEREAL FEED USE IN TAIWAN AND THE REPUBLIC OF KOREA

The use of cereal grains as livestock feed has increased sharply in Taiwan and the Republic of Korea, both of which are newly industrializing economies with rapidly growing per capita incomes and moderately high income levels. Changes in their consumption of food and feed are indicative of potential developments in other developing countries if they also achieve rapid economic growth.

Taiwan

In Taiwan, cereal feed use increased dramatically from 1950-52 to 1980-82.

Period (average)	Feed Use (1,000 metric tons)	Feeding Ratio
1950-52	69	0.6
1960-62	96	0.9
1970-72	1,302	2.8
1980-82	3,521	4.0

This phenomenal growth in feed use was a consequence of the changes in food consumption patterns that followed Taiwan's remarkable economic progress. During this period, per capita income increased an average of 6 to 7 percent a year and the population growth rate declined significantly from about 3.5 percent in the early 1950s to the present 2.0 percent per year.

Period (average)	Index of Per Capita Income (1976 = 100)	Population (millions)
1950-52	n.a.	8.4
1960-62	35	11.7
1970-72	72	14.9
1980-82	135	17.9

n.a. means not available.

In 1982, the population of Taiwan stood at 18.3 million with an average per capita income of U.S. $2,340.

During the second half of the 1930s, when Taiwan was under Japanese colonial rule, the average food consumption was less than 100 kilograms of cereal and 15 kilograms of meat per year. These foods, along with other components of the food basket, such as starchy roots, pulses, fruits and vegetables, milk, and fish, supplied 1,865 calories of energy and 45 grams of protein per day. By the second half of the 1940s, the average per capita cereal consumption had increased by 22 percent, but the intake of meat had declined to nearly half of 1935-39 levels. Steady recovery began in the early 1950s, when the per capita consumption of cereals rose to 140 kilograms and that of meat to 11 kilograms per year. Per capita consumption reached 2,068 calories and protein 47 grams per day. Cereal consumption peaked in the early 1970s at about 165 kilograms a year but then declined to 134 kilograms in 1980-82. The consumption of livestock products continued to increase steadily, reaching 26 kilograms of meat in 1970-72 and 41 kilograms in 1980-82. Per capita consumption of milk and eggs also increased dramatically. Total calorie intake rose to 2,700 calories per day, while intake of proteins increased to 77 grams by 1980-82. The proportion of animal proteins in the total protein intake also increased from 22 percent in 1950-52 to about 42 percent in 1980-82.

Far-reaching changes took place on the supply side also. In the second half of the 1930s, cereal production in Taiwan consisted almost entirely of rice, nearly 50 percent of which was exported, mostly to Japan. By the early 1950s, rice production reached 1.5 million tons, of which about 87,000 tons were exported, but the coun-

try imported about 70,000 tons of wheat to augment domestic cereal supplies. From then on, imports of wheat for direct consumption increased regularly, reaching nearly 300,000 tons by the early 1960s and about 670,000 tons by 1980-82. Production of rice also increased to 2 million tons by 1960-62. Thereafter, growth in rice production slowed; rice output hovered between 2.4 and 2.6 million tons in the 1970s. Taiwan, which normally produces only a small amount of coarse grain, increased its output from less than 40,000 tons in 1960-62 to about 125,000 tons in 1980-82. However, coarse grain imports increased from 18,000 tons to 3.6 million tons during the same period, mostly for use as livestock feed. As food consumption habits shifted toward a diet oriented to meat and other livestock products, imports of wheat showed only a small increase between 1970-72 and 1980-82. The country started exporting large quantities of rice in the late 1970s, reaching 430,000 tons in 1979. From a net exporter of cereals in 1950-52, Taiwan became a net importer, with net imports as a percentage of total domestic utilization increasing from 13 percent in 1960-62 to 58 percent in 1980-82. As stated, the bulk of imports in the 1980s were for livestock feed.

The increased demand for meat, milk, and eggs in Taiwan was largely met from domestic production. Meat output increased steadily from less than 100,000 tons in 1950-52 to 728,000 tons in 1980-82. More than 60 percent of this increase was in pigmeat, which rose from 80,000 to 470,000 tons during this period. Impressive increases were recorded in the output of milk and eggs as well. Milk output rose from less than 1,000 tons to about 52,000 tons, while output of eggs increased elevenfold to about 148,000 tons in 1980-82.

In LOUs, the output of livestock products increased from 108,000 tons in 1950-52 to 881,000 tons in 1980-82. Thus the feeding ratio—that is, the use of cereal feed per unit of livestock output—increased from 0.6 to about 4.0 during this period. Selected data on production and trade of cereals and livestock products are given in Table 12. Consumption data are given in Table 13.

Republic of Korea

Rapid increases in the output of livestock products also occurred in the Republic of Korea. Korea had an average per capita income growth rate of 7 percent a year during the last two decades, and the average per capita income was $1,910 in 1982.

Period (average)	Per Capita Income (1980 U.S. $)	Population (millions)
1961-65	523	26.7
1969-71	840	31.3
1979-81	1,567*	38.5

*In current prices.

Between the 1960s and the end of the 1970s, the output of meat increased at a rate exceeding 10 percent a year, rising from a little less than 100,000 tons during 1961-65 to about 516,000 tons during 1979-81. The growth in fresh milk production was even more phenomenal; it rose from about 7,000 tons to 452,000 tons. The output of eggs rose 5.5 times (Table 14).

To sustain this production growth, the quantity of cereals used as livestock feed increased from 229,000 tons in the early 1960s to more than 3 million tons during 1979-81. Of the latter, coarse grains—mostly imported—accounted for about 90 percent. Thus the feeding ratio increased from 1.6 to 3.7 during the period.

Period (average)	Feed Use (1,000 metric tons)	Feeding Ratio
1961-65	229	1.6
1969-71	725	2.4
1979-81	3,052	3.7

On average, the Republic of Korea produced 4.6 million tons of cereals during 1961-65, of which two-thirds was milled rice, about 30 percent was coarse grains, and the balance was wheat (Table 14). By 1969-71, rice production rose to 3.6 million tons, an increase of 16 percent over seven

Table 12—Average production and trade of cereals and livestock products, feed use, per capita income, and population, Taiwan, selected years

Variable	1950-52	1960-62	1970-72	1980-82
		(1,000 metric tons)		
Cereal production				
Rice (husked)	1,492	2,007	2,376	2,419
Wheat	17	44	3	3
Coarse grains	13	39	79	125
Total	1,522	2,089	2,457	2,547
Cereal exports				
Rice	86.9	63.9	38.2	213.6
Wheat	...	2.0	1.8	...
Coarse grains	...	...	...	...
Total[a]	86.9	65.9	40.0	213.6
Cereal imports				
Rice	...	46.1	2.4	4.7
Wheat	70.2	293.5	628.5	670.2
Coarse grains	...	18.2	1,208.1	3,585.5
Total[a]	70.2	357.8	1,839.0	4,260.4
Total available supply of cereals[b]	1,430.2	2,297.8	4,659.8	7,009.4
Net imports of cereals	−16.7[b]	291.9	1,788.9	4,046.8
Net imports as a share of total supply (percent)	...	12.70	38.39	57.73
Output of livestock products				
Meat	94	145	398	728
Milk	1	5	19	52
Eggs	13	19	64	148
Total in livestock output units	108	164	465	881

Source: Council for Agricultural Planning and Development, *Taiwan Food Balance Sheet, 1935-1980* (Taiwan: Republic of China, July, 1981). Data from 1981 onward were obtained from the Council separately.

Notes: Meat includes beef, buffalo, mutton, goat, pig, and poultry meat, all in carcass weight equivalents. Production and consumption were more or less the same, as the net trade in total meat use was almost negligible. Parts may not add to total due to rounding.

[a] Total available supply = production + changes in stock + imports − exports.

[b] This figure represents net exports.

years. Average output of rice reached 4.3 million tons during 1979-81, showing an average growth rate of 2.0 percent per year over the entire period. Coarse grains production rose much faster during the first period, but it declined thereafter. The average production during 1979-81 was even lower than that in 1961-65. The overall production of cereals, which increased at an average rate of 3.1 percent a year in the first period, declined by 1979-81, reducing the overall growth rate to 1.1 percent. This

Table 13—Per capita consumption per year, Taiwan, selected years

Years	Cereals	Meat	Milk	Eggs	Calories	Protein
		(kilograms)			(per day)	(grams/day)
1950-52	140	11.2	0.5	1.6	2,068	47
1960-62	161	12.0	1.3	1.6	2,345	58
1970-72	165	26.3	2.5	4.3	2,653	73
1980-82	134	40.6	5.8	8.2	2,706	77

Source: Council for Agricultural Planning and Development, *Taiwan Food Balance Sheet, 1935-1980* (Taiwan: Republic of China, July, 1981). Data from 1981 onward were obtained from the Council separately.

Table 14—Average production and trade of cereals and livestock products, Republic of Korea, selected years

Variable	1961-65	1969-71	1979-81
		(1,000 metric tons)	
Cereal production			
Rice	3,077.5	3,566.7	4,339.2
Wheat	169.8	213.0	64.0
Coarse grains	1,387.7	1,961.0	1,229.0
Total	4,635.0	5,740.8	5,632.2
Cereal exports			
Rice	17.4	...	...
Wheat	...	2.7	...
Coarse grains	0.5	4.8	1.0
Total	17.9	7.6	1.0
Cereal imports			
Rice	20.9	657.9	1,005.4
Wheat	523.5	1,541.3	1,848.0
Coarse grains	190.0	288.9	2,827.0
Total	734.4	2,488.0	5,680.4
Total domestic utilization of cereals[a]	5,208.4	7,621.4	10,933.4
Net imports of cereals	716.5	2,480.5	5,679.4
Net imports as a share of total domestic utilization (percent)	13.6	32.5	51.9
Output of livestock products			
Meat	98	163	516
Milk	7	53	452
Eggs	46	132	256
Total in livestock output units	144	300	817

Sources: Food and Agriculture Organization of the United Nations, (FAO), "Agriculture: Toward 200u Tape," Rome, 1981; FAO, *Food Balance Sheets, 1979-81 Average* (Rome: FAO, 1982); and FAO, "Agricultural Supply/Utilization Accounts Tape, 1981," Rome, 1982; and FAO, "Production Yearbook Tape, 1981." Rome, 1982.

Notes: The ellipses indicate nil or negligible. Parts may not add to total due to rounding.

[a] Total domestic utilization = production + net imports + change in stocks.

was nearly half of the population growth of 2.2 percent per year.

The increased demand for cereals both for domestic consumption as food and the derived demand for feed had to be met through imports. These imports increased eightfold from about 734,000 tons in 1961-65 to 5.7 million tons in 1979-81. About half of the imports during the latter period were for livestock feed and consisted of coarse grains. Thus net imports of cereals as a percentage of total domestic utilization increased from about 14 percent to 52 percent.

The per capita consumption of cereals also followed the expected path (see Table 15). Use of cereals for food rose from 178 kilograms per year in 1961-65 to 207 kilograms in 1969-71, but in the next decade it declined marginally to 205 kilograms. On the other hand, the per capita consumption of livestock products increased fourfold overall. Total consumption also increased during this period—by about 35 percent in calories and 50 percent in protein. The rapid increase in livestock production led to a substantial increase in the derived demand for cereal feed. Putting the food and feed uses of cereals together, total per capita use of cereals increased from 186 kilograms during 1961-65 to 284 kilograms in 1979-81, an increase of more than 50 percent. The share of cereal feed in total grain use also increased from 4 percent to 28 percent during the same period.

Table 15—Per capita consumption per year, Republic of Korea, various years

Years	Cereals	Meat	Milk	Eggs	Calories	Protein
		(kilograms)			(per day)	(grams/day)
1961-65	178	3.6	2.7	1.5	2,147	55
1969-71	207	5.2	4.6	3.8	2,539	67
1979-81	205	14.7	11.7	6.1	2,895	82

Sources: Food and Agriculture Organization of the United Nations, (FAO), "Agriculture: Toward 2000 Tape," Rome, 1981; FAO, *Food Balance Sheets, 1979-81 Average* (Rome: FAO, 1982); and FAO, "Agricultural Supply/Utilization Accounts Tape 1981," Rome, 1982.

Conclusions

To summarize the conditions favorable to a rapid rise in livestock output and the derived demand for cereal feed based on the experiences of Taiwan and Korea, first, both the economies had rapid growth in per capita incomes and their current income levels were in the upper middle range. Second, the per capita consumption of livestock products until the early 1960s was low and the income elasticity of demand for these products was high, which led to rapid growth in their aggregate demand. Third, both had potential for the development of livestock products, particularly pork and poultry meat, milk, and eggs. They imported new production technology from the developed countries and invested in capital-intensive commercial or semicommercial livestock enterprises. Fourth, neither Taiwan nor the Republic of Korea had large permanent pastures or grazing areas, and hence they had to depend on concentrate feeds. In both countries land is a constraint: domestic shortages in feedgrains were met through large-scale imports, and the feeding ratio increased rapidly. The infrastructure needed for processing, refrigerated storage, transport, and marketing of these perishable products was available in both. The two economies had rapid trade growth; thus foreign exchange was not a constraint. They preferred to import feeds and meet the increased demand through domestic production rather than importing livestock products from outside.

It is true that all these conditions may not be replicated in other developing countries. For example, in some of the medium- and high-income countries of Latin America, where current levels of per capita livestock consumption are relatively high, the income elasticity of demand for these products is lower, though still higher than that for cereals. Consequently, future growth in per capita demand for livestock products may not be as fast. Moreover, in some of the developing countries in Latin America and Sub-Saharan Africa where land is not scarce, the higher demand for feedgrains may be met from increased domestic production. What the Taiwanese and Korean experiences indicate is that with rapid increases in per capita income and high income elasticity of demand for livestock products, the derived demand for feedgrains grows rapidly, and the feeding ratio also rises rapidly.

6

DYNAMICS OF DEMAND FOR FOOD AND FEEDGRAINS IN SELECTED DEVELOPING COUNTRIES

Data presented in Chapter 4 show that the use of cereals for feed rose faster than food use between the late 1960s and late 1970s in Third World countries. Projections of demand for cereals and other food staples, based on income elasticities and the continuation of past income trends, suggest that this trend is likely to continue. The case studies of Taiwan and the Republic of Korea indicate that the derived demand for feed could grow even faster than past trends suggest. In general, as per capita incomes rise in developing countries, consumption of livestock products rises much faster because the income elasticity of demand for these products is much higher than that for direct consumption of cereals. This could lead to a rapid rise in the derived demand for feed, particularly in countries where the increased domestic demand for livestock products is met through accelerated domestic production. In addition, the feeding ratio, that is, the average quantity of cereals used to produce one unit of livestock products, increases because of changes in the composition and structure of livestock products and feeds.

The proportion of poultry and pigmeat in the total output of meat has increased significantly in recent years. In developing countries, poultry, pork, and dairy enterprises are increasingly organized along commercial or semicommercial lines. They use more compound and mixed feeds, which have cereals as a major component. These enterprises are no longer backyard operations that rely on farmyard and household wastes and by-products. To meet the increased demand for compound and mixed feeds, the feed manufacturing industry is developing rapidly, leading to larger demand for feedgrains and consequently to higher average feeding ratios in livestock production.

Further, the income elasticity coefficient for livestock products, particularly poultry and eggs, remains relatively stable at one or a little above one in many developing countries (see Appendix 3, Table 28). At low incomes, the per capita consumption of livestock products is small, and hence the derived demand for cereals for feed is small compared with that for direct food consumption. As incomes rise, the elasticity coefficient for cereals for direct food consumption declines; the much higher income elasticity of derived demand for cereals arising from livestock products may also decline but less rapidly. Although feedgrains' share of the total domestic utilization of cereals is still small in many developing countries, it seems likely that it will grow rapidly, leading to a decline in the share of cereals used for food. Thus the behavior of the average income elasticity of demand for grains requires careful study. When the weighted average elasticity is high, especially in Third World countries with rapid per capita income growth and moderately high population growth, aggregate demand for grains would increase rapidly. Where this demand is not matched by increased domestic production, cereal imports could increase substantially.[16] Here the conditions under

[16] Mellor, John W. "Third World Development: Food, Employment and Growth Interactions," *American Journal of Agricultural Economics* 64 (May 1982): 304-311; and John W. Mellor and Bruce F. Johnston, "The World Food Equation: Interrelations Among Development, Employment, and Food Consumption," *Journal of Economic Literature* 22 (June 1984): 531-574.

which the combined demand for grains would increase rapidly are examined analytically and tested with empirical data.

Total Demand for Grains

The total demand for grain in year t, D_t, is the product of population, P_t, and per capita consumption, C_t:

$$D_t = P_t C_t. \quad (1)$$

Further,

$$P_t = P_0(1 + r_p)^t, \quad (2)$$

$$C_t = C_0(1 + r_c)^t, \text{ and} \quad (3)$$

$$r_c = (dc/dt)/c = [(dc/dy)(y/c)]$$
$$[(dy/dt)(1/y)] = \eta_g r_y, \quad (4)$$

where

P_0 = the popuiation in base period 0,

C_0 = the per capita consumption in base period 0,

r_p = the rate of growth of population,

r_c = the rate of growth of per capita consumption,

c = per capita consumption,

y = per capita income,

η_g = the income elasticity of demand for grain, and

r_y = the rate of growth of per capita income.

Equations (2), (3), and (4) can be substituted into equation (1) to give[17]

$$D_t = P_0 C_0[(1 + r_{pt})^t(1 + \eta_{gt} r_{yt})^t] \quad (5)$$

where r_{pt} and r_{yt} are the rates of growth in population and per capita income, and η_{gt} is the income elasticity in period t.

The income elasticity for grain, η_g, is a weighted average of the elasticities of food (η_f) and feed (η_η) with β and $(1 - \beta)$ as weights, where β represents the share of food and $(1 - \beta)$ is the share of feed in total grain use,[18] or

$$\eta_g = \beta\eta_f + (1 - \beta)\eta_\eta. \quad (6)$$

The demand for feedgrains for, say, meat production is equal to the demand for meat (g_3) multiplied by the feeding ratio (α) or the amount of feed required to produce one unit of meat. Then the income elasticity of demand for feed equals the sum of income elasticities of meat (η_m) and the relative change in the feeding ratio to the percentage change in per capita income (η_α):[19]

$$\eta_\eta = \eta_m + \eta_\alpha. \quad (7)$$

If equations (6) and (7) are combined, the income elasticity of demand for total grains equals

$$\eta_g = \beta\eta_f + (1 - \beta)(\eta_m + \eta_\alpha). \quad (8)$$

Example 1

This example and the ones that follow merely illustrate the behavior of these vari-

[17] If η_g and r_y are not constant over time, every time η_g or r_y or both change, r_c will also change. Thus the rate of growth in per capita consumption over time period t is given by $r_{ct} = \eta_{gt} \times r_{yt}$, where η_{gt} and r_{yt} also relate to time period t.

[18] The total demand for grain, g, is the sum of demand for food (g_1) and feed use (g_2). Thus $g = g_1 + g_2$; $(dg/g) = (g_1/g)dg_1 + (g_2/g)dg_2 = \beta dg_1 + (1 - \beta)dg_2$. Dividing both sides by (dy/y), $\eta_g = \beta \times \eta_f + (1 - \beta) \times \eta_\eta$. Total domestic utilization of grain also includes its use for seed, nonfood industrial uses, and allowance for wastage. These are not considered here for the sake of simplicity.

[19] Thus, $g_2 = \alpha g_3$, $dg_2/g_2 = dg_3/g_3 + d\alpha/\alpha$. Dividing throughout by (dy/y), $\eta_\eta = \eta_m + \eta_\alpha$.
Here meat is taken to represent the livestock output; milk and eggs are not considered.

ables and do not necessarily represent the actual conditions in any particular country. Scenario 1 in Table 16 shows the behavior of η_g as η_f declines for different values of β and for the constant value of $\eta_m = 1.0$, assuming that $\eta_\alpha = 0$ and hence $\eta_\eta = 1$.[20]

The combined elasticity first decreases and then increases. The combined elasticity increases rapidly when the ratio of feed to food plus feed increases (or the value of β declines).

Example 2

The values of η_f and β are assumed to remain the same in two other cases, scenarios 2 and 3. In scenario 2, η_α and η_m are taken to equal 1 and hence $\eta_\eta = 2$ (constant). This implies that, associated with a 1 percent increase in per capita income, the feeding ratio also increases by 1 percent. In scenario 3, $\eta_\alpha = 0$ and η_η decreases. The computed values of η_g are given in Table 16.

In scenario 2, where $\eta_\eta = 2$ (constant), η_g increases continuously. In the third scenario where η_η and η_m decrease, η_g first decreases, then increases, and finally decreases. Declining elasticities of meat occur when meat consumption is already high, as in parts of Latin America.

The two examples given above show that apart from the values of η_f, η_m, and η_η, the behavior of β also influences the changes in η_g.

The magnitude of the change in β depends on the initial values of β, η_f, η_η and the rate of change in per capita income (dy/y), as equation (10) shows:

$$\beta = g_1/g;\ d\beta = (dg_1/g) - (g_1 dg/g^2). \qquad (9)$$

Thus

$$d\beta/\beta = (dg_1/g_1) - (dg/g)$$
$$= (\eta_f - \eta_g)(dy/y).[21] \qquad (10)$$

Example 3

For values of $\beta = 0.95$, $\eta_f = 0.22$, and $\eta_\eta = 1.00$, the decrease in β associated with a 4 percent increase in per capita income will be 0.0015 per year. The same figure works out to be about 0.0095 per year where $\beta = 0.50$, $\eta_f = 0.05$, and $\eta_\eta = 1.00$.

The changes in η_g with changes in per capita income are given by the inequality

$$d\eta_g/dy \gtreqless 0. \qquad (11)$$

Table 16—Three scenarios for income elasticities of demand

Constant		Scenario 1		Scenario 2		Scenario 3	
η_f	β	$\eta_\eta = 1$	η_g	η'_η	η'_g	η''_η	η''_g
0.22	0.95	1.00	0.259	2.00	0.309	1.00	0.259
0.15	0.90	1.00	0.235	2.00	0.335	0.80	0.215
0.10	0.75	1.00	0.325	2.00	0.575	0.64	0.235
0.05	0.50	1.00	0.525	2.00	1.025	0.40	0.225

[20] The assumption that $\eta_\alpha = 0$ implies that the average feeding ratio remains unchanged throughout the projection period.

[21] Dividing both sides of (9) by (dy/y), one obtains

$$(d\beta/\beta) \div (dy/y) = [(dg_1/g_1) \div (dy/y)] - [(dg/g) \div (dy/y)] = \eta_f - \eta_g.$$

Differentiating equation (6) with respect to y,

$$\begin{aligned} d\eta_g/dy &= (d\beta/dy)\eta_f + \beta(d\eta_f/dy) \\ &\quad + [d(1-\beta)/dy]\eta_\eta \\ &\quad + (1-\beta)(d\eta_\eta/dy) \\ &= (d\beta/dy)(\eta_f - \eta_\eta) \\ &\quad + \beta(d\eta_f/dy) \\ &\quad + (1-\beta)(d\eta_\eta/dy). \end{aligned} \tag{12}$$

From empirical evidence, in the developing countries generally $\eta_\eta > \eta_f$; and hence $\eta_f - \eta_\eta$ is negative. As incomes increase, β usually decreases, and hence $d\beta$ is negative.

Thus the first term is positive. η_f is constant or decreases. The second term is zero or negative. Further, if η_η is constant, $d\eta_\eta$ is zero, and hence the third term is zero.

Then, η_g decreases or increases if

$$|\beta(d\eta_f/dy)| \gtrless |(d\beta/dy)(\eta_f - \eta_\eta)|. \tag{13}$$

When η_η decreases, then η_g decreases or increases if

$$|\beta(d\eta_f/dy)| + |(1-\beta)(d\eta_\eta/dy)| \gtrless |(d\beta/dy)(\eta_f - \eta_\eta)|. \tag{14}$$

Thus the behavioir of η_g is determined by the inequalities (13) and (14).

Example 4

To determine the precise effects of growth components on overall growth is complex and varies from country to country. To illustrate, the grain demand for feed use was projected for 12 selected countries assuming that the income elasticity of meat is a proxy for feed elasticity. Data on the projected growth rates of utilization of cereals for food and feed based on this assumption are given in Table 17.

Table 17 shows that if past income trends continue, the overall demand for grains in Kenya is projected to grow between 1980 and 2000 at 5.1 percent a year and in Nigeria at 4.7 percent a year. In Kenya and Nigeria, population growth is the major contributing factor. In Indonesia, demand is expected to grow less than 2 percent a year. In all the other countries, demand would grow between 2.0 and 4.0 percent a year. In Turkey, the combined food and feed elasticity is high at about 0.5.

Growth in Foodgrain Use. The income elasticity of demand for foodgrains, η_f, is low and is declining in a number of developing countries. The average implied income elasticity during the 1980-2000 period is negative in 5 out of the 12 countries: Indonesia, Thailand, Malaysia, Turkey, and Mexico.[22] In India and the Philippines η_f lies between 0.20 and 0.24, and in the Republic of Korea it is very small. In the remaining four countries, η_f is positive and less than 0.20 (also see Appendix 3, Table 28). Taking into account the effects of population and income growth, the projected growth in food use of cereals exceeds 4 percent per year in Kenya and Nigeria, and it lies between 2 and 3 percent in India, Egypt, the Philippines, and Brazil. In the remaining six countries growth in the demand for cereals for food use is projected at less than 2 percent per year. Even in the five countries where η_f is negative, food demand would still increase because of population growth. And the combined elasticity for food and feed is positive in these countries.

Growth in Feed Use. The income elasticity of demand for feed use with that for meat as a proxy is more than unity in 3 out of the 12 countries.[23] In Indonesia and Nigeria, the projected feed growth exceeds 8 percent per year. In India, however, al-

[22] Subsequent evidence shows that the income elasticity for cereals is found to be positive in Indonesia and higher than that based on FAO data.

[23] The income elasticity coefficients given in Appendix 3, Table 28 represent the values by type of meat, whereas those in Table 17 relate to implied elasticities derived from the total projected demand for meat.

Table 17—Projected growth in food and feed use of cereals, 1980-2000 and average income elasticity of demand for food and feed, selected countries

Selected Country	Per Capita Income[a] 1980	Population Growth[b] 1980-2000	Per Capita GNP Growth[c] 1980-2000	Feed Growth 1980-2000	Food Growth 1980-2000	Feed and Food Growth 1980-2000	Feed/Feed and Food		Average Feed Elasticity[f] 1980-2000	Average Food Elasticity[g] 1980-2000	Average Combined Elasticity 1980-2000
							1980[d]	2000[e]			
	(U.S. $)		(percent)								
India	223	1.68	1.51	3.42	2.05	2.20	0.10	0.13	1.13	0.24	0.34
Kenya	393	4.25	2.68	6.74	4.65	5.06	0.17	0.23	0.89	0.14	0.29
Indonesia	441	1.53	5.14	8.16	0.66	1.92	0.09	0.29	1.27	−0.17	0.07
Egypt	522	2.32	3.87	5.84	2.41	3.52	0.26	0.40	0.89	0.02	0.30
Thailand	688	1.78	4.35	3.61	1.50	2.06	0.23	0.31	0.41	−0.06	0.06
Philippines	696	2.21	3.38	4.66	2.93	3.32	0.20	0.26	0.71	0.21	0.32
Nigeria	925	3.55	4.55	8.31	4.32	4.72	0.07	0.14	1.01	0.16	0.25
Turkey	1,524	2.18	3.52	5.63	1.00	3.90	0.53	0.73	0.96	−0.33	0.48
Korea, Republic of	1,696	1.31	6.00	4.15	1.31	2.31	0.29	0.42	0.47	0.00	0.16
Malaysia	1,560	2.00	4.61	5.01	1.61	3.03	0.34	0.50	0.64	−0.08	0.22
Brazil	2,061	1.98	6.00	4.61	2.48	3.80	0.57	0.67	0.43	0.08	0.30
Mexico	2,623	2.29	3.60	4.41	1.92	3.25	0.48	0.60	0.58	−0.10	0.26

Sources: Calculated from computer printouts used in Leonardo A. Paulino, *Food in the Third World: Past Trends and Projections to 2000,* Research Report 52 (Washington, D.C.: International Food Policy Research Institute, 1986). GNP data are from World Bank, "Gross National Product by Country Data Tape, 1961-80," Washington, D.C., 1981; and population data are from United Nations, Department of International Economic and Social Affairs, "World Population Prospects as Assessed in 1982," New York, 1983 (computer printout).

[a] Per capita income is based on the 1961-80 trend of GNP in real terms (1979-81 = 100).

[b] Population growth is based on United Nations medium-term population projections, as assessed in 1982.

[c] Per capita GNP is based on 1966-80 trend growth in per capita income. An upper limit of 6 percent was imposed on per capita income growth in projecting it for 1980-2000.

[d] 1980 data relate to trend values.

[e] This is based on projected values of food and feed in 2000. Other uses of cereals, namely seed and waste, are not considered.

[f] The average elasticity of demand for feed is the same as the average elasticity of demand for meat, worked out on the basis of the implied growth rate in projected per capita meat consumption between 1980 and 2000.

[g] The average elasticity of demand for food is based on the implied growth rate in projected per capita cereal consumption between 1980 and 2000.

though η_η is high, the rate of growth in per capita income is low; hence feed growth is about 3.4 percent. In Turkey and Kenya, where η_η is a little less than unity, the projected rates work out to 5.6 and 6.7 percent respectively. In the high-income countries of Brazil and Mexico, η_η is less than 0.6. In spite of Brazil's high income growth and Mexico's high population growth, feed projections show 4.6 and 4.4 percent growth rates respectively. Because of low population growth in the Republic of Korea, feed growth works out to 4.2 percent, despite the high income growth and 0.5 feed elasticity.

Behavior of β Ratios

Appendix 3, Table 29 gives the ratios of the amount of grains for food use to the combined amount for food and feed use in the 12 selected countries, calculated on the basis of the elasticities referred to above. These indicators confirm the earlier observation that in Turkey, Brazil, and Mexico, where the βs were relatively low in 1980, they will decline much faster by 2000, and that in countries where the initial βs are high, the decline is much slower.

Conclusions

This analysis shows that projecting the behavior of the overall demand for grains is quite complex and that the conclusions are sensitive to the assumptions made with regard to the various growth elements. Assuming that meat elasticity is a proxy for feed elasticity implies that the feeding ratio is constant, which is not the case in some Third World countries. Feeding ratios do change rapidly, as in Taiwan and the Republic of Korea, for example. For this reason, the resulting projections probably underestimate the potential growth rates of demand for feedgrains.

7

PROJECTIONS OF CEREAL FEED USE IN DEVELOPING COUNTRIES

Any assessment of the total future demand for cereals for livestock feed should ideally take into consideration the desirable composition of feed in terms of cereals, noncereal feeds, fodders, forages, and crop byproducts. The projected livestock output should also be considered by type, and the feed required to produce it in terms of metabolic energy, protein, and total digestible nutrients based on average feeding schedules. In addition, prices of alternative feeds, scope for improving the efficiency of feed use, and the relationship between input and output prices have to be kept in view.

One approach for estimating feed requirements is to use a regression framework that defines cereal feed use as a function of a number of variables and to determine the relevant coefficients quantitatively based on cross-section or time-series data. The variables might include per capita income; prices; size, composition, and output of the livestock sector; and availability of pastures. However, the poor quality of the data on feed use and some of the other relevant variables in a majority of the developing countries precluded the adoption of this approach. Alternative rough and ready methods, based largely on projected livestock outputs, feeding ratios, or extrapolation of past trends, where appropriate, were adopted instead.

In IFPRI's study of livestock products, the output of meat, milk, and eggs were each projected to 1990 and 2000, based on the continuation of past trends in the output for each country during 1961-77.[24] These projected outputs were then converted into LOUs, as explained in Chapter 3, and aggregated for each subregion. These subregional aggregates multiplied by the corresponding feeding ratios give the requirements of cereal feed in 1990 and 2000. The projected feeding ratios for the years 1990 and 2000 were obtained as extrapolations of the linear trends fitted to the annual data on feeding ratios, which in turn were calculated by dividing the actual feed use (as reported in FAO's "Agricultural Supply/Utilization Accounts") in each year by the corresponding livestock output units for the period 1966-80. This is the first method.

In developing countries in the past, aggregate use of cereal feeds expanded faster than output of livestock products in 10 out of 12 subregions. The second method is based on the assumption that this difference in growth rates will continue, provided observed changes in the composition and structure of meat and milk output and current production techniques continue. To reflect these changes, the projected growth rate implied by the livestock output projections for 1980-2000 was first calculated for each subregion. Next, the difference between the 1966-80 trend growth rate of cereal feed use and that of livestock output (expressed in LOUs) in the subregion were computed. The difference was added to the 1980-2000 growth rate of livestock output. The adjusted growth rate for cereal feed thus obtained was then applied to 1980 trend estimates of cereal feed use in each subregion to obtain the projected feed use in 1990 and 2000.

Another approach, which involved trend projection of time-series data on cereal feed use for each country during the period 1966-80, was also tried. In the methodology for trend projections adopted by IFPRI, output projections are based on an extrapolation of past trends, assuming unchanged relative

[24] Sarma and Yeung, *Livestock Products in the Third World*.

prices. This method was adopted both for staple food crops and livestock products. Because the requirements of cereal feeds represent the derived demand for their conversion into livestock products, a similar approach was adopted for projecting feed use. A close examination of the fitted exponential trend equations showed deficiencies in several countries. Either the R^2 was too low or the coefficients were not significant, particularly in countries that used only small quantities of feed. In some countries especially in Sub-Saharan Africa, growth rates were extremely high mainly because of data problems; extrapolation of these trends to 1990 and 2000 would have led to unrealistically high estimates unless upper limits to future growth were arbitrarily fixed. In order to surmount these difficulties, two modifications were adopted. First, the data were grouped by subregions, and trend growth rates were calculated based on the annual aggregate feed use in each subregion for the period 1966-80.[25] These growth rates were extrapolated to give the projected feed use in 1990 and 2000, under the third method.

It was further noted that in 29 out of 104 countries cereal feed use exceeded 500,000 tons in 1980, and aggregate feed use in these countries formed 90 percent of the Third World total (Appendix 3, Table 30). In the fourth method, cereal feed use in each of these 29 countries was individually projected. The remaining 75 countries were grouped by level of per capita income into four classes: less than $250, between $250 and $499, between $500 and $1,999, and $2,000 and more. The cereal feed use in each group was projected separately. The projected values were added to give the aggregate projected feed use for the 104 countries.

In both the third and fourth methods, the period 1966-80 is used as a data base for growth rate projections. Questions have been raised on whether this is an appropriate base period. It has been argued that per capita incomes in developing countries rose very rapidly during most of this period, and the consumption of livestock products also increased rapidly. If economic growth slows, the demand for these products may not grow as quickly.[26] It is true that as the result of improvements in agricultural technologies and institutions, increasing adoption of outward-looking industrial policies, and favorable external conditions, the 1966-73 period witnessed high economic growth in some developing countries. Subsequently, however, the oil shocks of 1974 and 1979-80, the ensuing recession and protectionism in the countries belonging to the Organization for Economic Cooperation and Development (OECD), and mounting debt repayment problems slowed economic growth in the developing countries. There are, however, indications of economic recovery. The average economic growth during 1966-80 seemed to be one that developing countries could achieve through the structural adjustments that are now being undertaken in several developing countries. These promise improvements in the efficiency with which resources are allocated and used, thus enhancing the prospects for better economic performance in the future.

Moreover, growth in the use of cereal feed is related to growth in the output of livestock products, particularly poultry, pigmeat, eggs, and milk. As long as trends in these products continue, the derived demand for feed will also continue to grow rapidly. Analysis of more recent trends in the output of livestock products in developing countries (excluding China) during the period 1973-75 to 1982-84 shows further acceleration in the growth rate of meat, milk, and egg output.[27]

The fifth method is that adopted in the IFPRI research report by Leonardo Paulino,

[25] This is based on the assumption that statistical errors tend to be compensated for in aggregates.

[26] These questions are discussed more fully in Sarma and Yeung, *Livestock Products in the Third World.*

[27] The average output of meat increased from 22.1 million tons in 1974-76 to 29.6 million tons in 1982-84—an average annual rate of 3.7 percent. For milk, the average increase was 2.8 percent a year from 87.1 million tons to 108.4 million tons over the same period. Production of eggs also accelerated, growing 6.1 percent a year and rising from 4.3 million tons to 7.0 million tons.

Food in the Third World. In estimating the projected animal feed use in 2000, the income elasticity of demand for meat was used as a proxy for that of feed. However, because the report gave the projected feed use of major food crops as a group, the cereal component was calculated for 1990 and 2000, using the same method. Thus trend estimates of per capita use of cereal feed in 1980 were obtained, and these were projected to 1990 and 2000, using trend per capita income growth and income elasticity of demand. This approach to projecting the derived demand for animal feed essentially assumes that feed use in a country would grow as fast as the demand for meat. Projected feed use would be overestimated in countries where meat consumption growth is faster than growth of production and underestimated in countries where production growth rates are faster. Further, to the extent that income growth during the early 1980s is lower than the 1966-80 trend and is not compensated for by faster economic growth during the remainder of the decade, consumption of livestock products may not grow as fast as projected; thus the calculated demand for feed based on the elasticity of meat may also be delayed in reaching projected levels.

It was seen in Chapter 6 that estimating feed requirements using the income elasticity of meat as a proxy for feed elasticity implies that the feeding ratio would be constant during the projection period. If the feeding ratio increases, as it did in Taiwan and the Republic of Korea, the projected estimates using this method would be too low. This method also assumes that income elasticity of meat represents the combined elasticity of meat, milk, and eggs. Thus, although the fifth method has the advantage of easy conceptualization and computation, the projections under this method have their limitations as well. Details of these five methods are given in Appendix 1.

Table 18 and Figure 4 show trend estimates for cereal feed use in 1980, calculated as the aggregate of subregional trend values, and the projected cereal feed use in 1990 and 2000, based on the five alternative methods.

If historical trends in the output of livestock products continue, developing countries are projected to produce 51 million tons of meat, 178 million tons of milk, and 15 million tons of eggs, a little more than 83 million tons in LOUs by the end of the century. Using the first method, the average projected feeding ratio for 2000 works out to a little more than 2.9. Thus the estimated level of cereal feed use for the Third World would amount to about 245 million tons, which is roughly two-and-a-half times the level reached in 1980. This implies an annual growth rate of about 4.7 percent. The estimate for 1990 indicates a 50 percent increase over 1980. Nearly 46 percent of estimated cereal feed use in 2000 would be in Latin America, 28 percent in Asia, 23 percent in North Africa/Middle East, and the balance in Sub-Saharan Africa.

Among the subregions, rapid growth in feed use exceeding 6 percent per year is projected for North Africa and for Central America (which includes Mexico and the Caribbean) if the existing trends in livestock output are maintained (see Appendix 3, Table 31). Lower South America at 1.5 percent and South Asia at 2.0 percent would have the slowest growth. In both these subregions the growth in livestock output between 1980 and 2000 is projected to be relatively low, and the rate of growth in feed use during 1966-80 was less than the corresponding growth in livestock output.

If, instead of dividing milk by 10 and adding meat and eggs to arrive at the aggregate livestock production in LOUs, the alternative procedure of converting all livestock products into Physiological Fuel Values discussed in Chapter 3 is adopted, and the same methodology is adopted for projecting feed requirements, the projected levels of feed use come to 153 million tons in 1990 and 251 million tons in 2000. The latter represents a 2.4 percent increase over the estimate under the former procedure for 2000.

Using the second method, the projected levels of livestock output represent an annual compound growth rate of 3.7 percent between 1980 and 2000. Adding to this the difference between LOUs and feed growth

Table 18—Cereal feed use projections under alternative assumptions, by region, 1990 and 2000

Method	Year	Rate of Growth[a]	Total 104 Countries	Asia	North Africa/ Middle East	Sub-Saharan Africa	Latin America
		(percent)			(million metric tons)		
Trend base	1980	n.a.	98.1	30.7	21.7	4.0	41.7
Method 1	1990	4.4	150.6	44.3	33.8	5.8	66.7
	2000	4.7	244.9	68.4	56.3	8.5	111.6
Method 2	1990	5.0	160.2	46.4	36.9	5.9	71.0
	2000	5.2	269.5	72.1	63.7	8.6	125.2
Method 3	1990	5.0	159.2	47.2	35.3	5.5	71.1
	2000	5.1	265.5	73.9	58.2	7.5	125.9
Method 4	1990	5.2	162.5	n.a.	n.a.	n.a.	n.a.
	2000	5.5	285.6	n.a.	n.a.	n.a.	n.a.
Method 5	1990	4.8	156.9	47.8	39.6	6.7	62.9
	2000	4.7	244.6	72.6	69.9	11.7	90.4

Sources: Food and Agriculture Organization of the United Nations, "Production Yearbook Tape, 1981," Rome, 1982; Food and Agriculture Organization of the United Nations, "Agricultural Supply/Utilization Accounts Tape, 1981," Rome, 1982; J. S. Sarma and Patrick Yeung, *Livestock Products in the Third World: Past Trends and Projections to 1990 and 2000*, Research Report 49 (Washington, D.C.: International Food Policy Research Institute, 1985); World Bank, "Gross National Product by Country Data Tape, 1961-80," Washington, D.C., 1981; and computer printouts used in Leonardo A. Paulino, *Food in the Third World: Past Trends and Projections to 2000*, Research Report 52 (Washington, D.C.: International Food Policy Research Institute, 1986).

Notes: Parts may not add to total due to rounding. n.a. indicates not applicable. Method 1 is based on projected values of the feeding ratio in 1990 and 2000 applied to the projected value of livestock output units (LOUs) in 1990 and 2000. Method 2 is an extrapolation of 1980 trend value of feed use, using the growth rate of LOUs in 1980-1990/2000 adjusted for the difference between the feed use growth and LOU growth during 1966-80. Method 3 is an extrapolation of the 1980 trend values of feed use in each subregion, based on 1966-80 trend growth. Method 4 is an extrapolation of 1980 trend values of feed use in 29 individual countries and the rest of the countries grouped by per capita income level. Method 5 uses the income elasticity of demand for meat as a proxy for the income elasticity of derived demand for feed.

[a] This is the rate of growth between 1980 and 1990/2000.

rates, the use of cereal feed is estimated to increase at about 5.2 percent a year, reaching about 270 million tons in 2000 compared with 245 million tons under the first method. The projected level in 1990 is about 160 million tons, which is about 10 million tons higher than in the first method. The regional distribution of feed use is similar under the first and second methods.

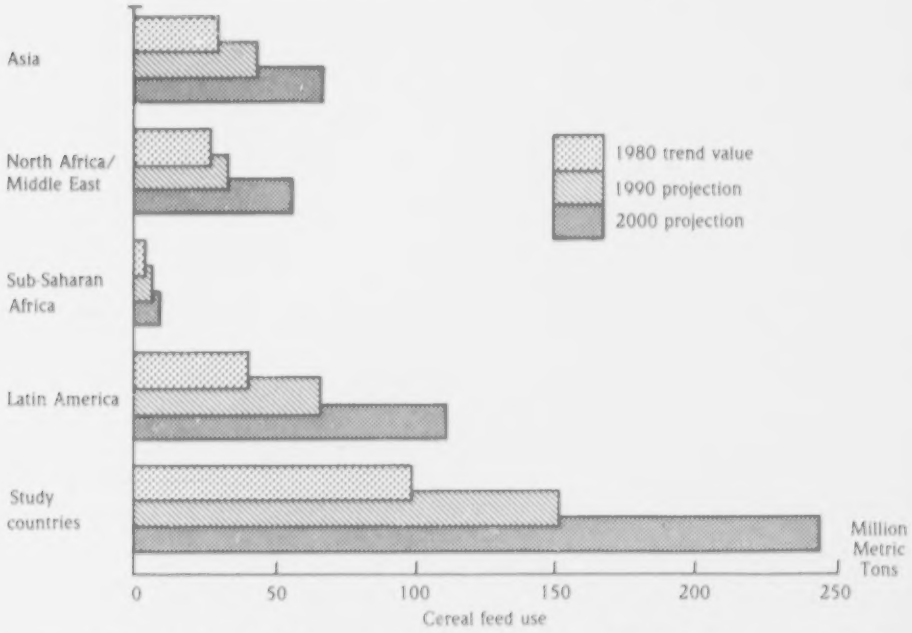
Subregional trend projections proposed under the third method indicate that the estimated feed use in 1990 and 2000 would be 160 and 265 million tons respectively. The projections are close to those under the second method. At 5.1 percent a year, the projected growth rate between 1980 and 2000 is slightly less.

The trend projections of feed use for the 29 individual countries and the grouped aggregates for the other countries envisaged under the fourth method would put the estimated feed use in 2000 at 286 million tons, implying an average growth rate of 5.5 percent a year. This is the highest among the five estimates. The 29 countries would have a total feed use of 261 million tons in 2000. The rest of the countries would share 25 million tons by the end of the century, as shown in Table 19.

Under method 5, which is based on the IFPRI food gap study,[28] the projected cereal feed demand is 157 million tons in 1990 and 245 million tons in 2000, implying growth rates of 4.8 and 4.7 percent respec-

[28] Paulino, *Food in the Third World*.

Figure 4—Trend cereal feed use in 1980 and projections to 1990 and 2000, by region, based on projected livestock output



Sources: Calculated from Food and Agriculture Organization of the United Nations, "Production Yearbook Tape, 1981," Rome, 1982; and Food and Agriculture Organization of the United Nations, "Agricultural Supply/Utilization Accounts Tape, 1981," Rome, 1982.

Table 19—Projected cereal feed use in 75 selected countries, by per capita income groups, 1990 and 2000

Per Capita Income Group	Rate of Growth, 1966-80	Projected Cereal Feed Use		
		1980	1990	2000
	(percent/year)	(million metric tons)		
Less than $250	0.3	1.50	1.55	1.59
$250–$499	3.8	1.98	2.88	4.20
$500–$1,999	5.1	4.26	7.01	11.52
$2,000 or or more	6.3	2.26	4.16	7.66
Total 75 countries	4.7	9.99	15.59	24.97

Source: Food and Agriculture Organization of the United Nations, "Agricultural Supply/Utilization Accounts Tape, 1981," Rome, 1982; and World Bank, "Gross National Product by Country Data Tape, 1961-80," Washington, D.C., 1981.

Note: Parts may not add to total due to rounding.

tively over the trend value in 1980. Although the projected Third World demand for feed in 2000 under methods 1 and 5 is very nearly the same, the regional distribution of this demand is different. Under method 5, Latin America's share of the total comes to about 37 percent, nearly 9 percent lower than under the first method. North Africa/Middle East accounts for less than 29 percent, which is about 6 percent higher than under the first method.

Among the 29 countries for which feed use is individually extrapolated under method 4, the projected levels of feed use are quite high in Mexico, the Republic of Korea, and Venezuela compared to those under the fifth method, whereas in Turkey the projected level is much lower. Moreover, in four countries, namely Colombia, the Republic of Korea, Saudi Arabia, and Venezuela, where

1966-80 trend growth of cereal feed exceeded 10 percent a year, a constraint of 10 percent was imposed in extrapolating for 1990 and 2000. The aggregate projected demand depends upon the level at which the constraint is placed.

Thus, these five methods of projection give a range of feed demand varying from 151 million to 163 million tons in 1990 and from 245 million to 286 million tons in 2000. The results under methods 1 and 5 are close in 2000. These imply an average growth rate of 4.7 to 5.5 percent a year between 1980 and 2000. The corresponding feeding ratio would range from 2.9 to 3.4, as compared to 2.4 in 1980.

Comparison with FAO Results

The FAO global study *Agriculture: Toward 2000* also covered livestock products, but apart from providing a broad indication of projected growth in cereal feed use for 90 developing countries, it does not go into details on feed projections.[29] The estimates are given under two scenarios: an optimistic scenario A and a medium growth scenario B. According to these indications cereal feed is projected to grow at annual rates of 5.7 and 4.8 percent between 1980 and 2000, under scenarios A and B respectively. These compare with IFPRI projections of 5.5 and 4.7 percent annual growth under methods 4 and 1.

[29] Food and Agriculture Organization of the United Nations, *Agriculture: Toward 2000* (Rome: FAO, 1981).

8

CONCLUSIONS AND POLICY IMPLICATIONS

IFPRI's projections of the Third World food gap based on the continuation of 1961-80 trends in production and 1966-80 trends in per capita income show that the developing countries (excluding China) could have an overall net food deficit of 76 million tons of basic food staples, including cereals and other food crops, at the end of the century.[30] They also indicate that although Asia could have a net surplus, the other three regions are likely to have net deficits—sizable deficits in North Africa/Middle East and Sub-Saharan Africa. These estimates are based on the projected total domestic utilization of 874 million tons of cereals and 172 million tons of other staple food crops. Of these, the projected demand for livestock feed is estimated at about 245 million tons of cereals and 23 million tons of other staple food crops.[31] The analysis in the preceding chapter has shown that if past trends in livestock production and use of cereals for feed continue, the derived demand for cereals for feed could rise to about 285 million tons under method 4, an increase of 40 million tons.

Implications of Accelerated Livestock Production

There are, however, some factors that may cause cereal feed use at the end of the century to be even larger than projected under method 1, which is related to the projected output of livestock products in 2000. For example, IFPRI's analysis of livestock consumption in the Third World shows that if per capita incomes in the developing countries continue to rise at rates attained during 1966-77, trend projected output of meat and milk would fall considerably short of demand at constant prices by the end of the century, even though output increased at 1961-77 trend growth rates. Meat and milk output growth rates would have to be raised 50 percent higher to balance the demand in the developing countries.[32] Even under an alternative scenario that projects a 25 percent slower growth in per capita income than the 1966-77 trend, the gaps between projected production and consumption of meat and milk would still be large, and domestic production would have to expand at rates higher than the 1961-77 trends to meet the projected demand.[33] In either case, the derived demand for cereal feed could be large, leading to even larger cereal deficits.

Between the early 1960s and mid-1970s, the 3.2 percent growth in consumption of meat was faster than production in developing countries, which rose at an average rate of 2.9 percent a year. The increase in domestic demand is reflected in the net exports of meat by Third World countries, which declined from 760,000 tons in the early 1960s to 300,000 tons in the mid-1970s. Developing countries had already become net importers of meat by the end of the 1970s. Using accelerated domestic production to substitute for imports would result in more rapid growth in feed use. Value added in the processing and manufac-

[30] Paulino, *Food in the Third World.*

[31] Ibid. This study projected the output of major food crops as a group, not separately for cereals and noncereals. Hence separate estimates of projected deficits in cereals are not available.

[32] Sarma and Yeung, *Livestock Products in the Third World.*

[33] Ibid. Part of the gap could be filled through imports from developed countries, but some of the developing countries might decide to meet the increased demand through increased domestic production. The basis for the two income trend scenarios is discussed in Chapter 7 of that report. Further, these projections of demand and supply assume constant relative prices.

ture of meat, eggs, and dairy products is high; thus developing countries may wish to make this substitution.[34] Taste preference for fresh meat and eggs, instead of imported frozen or packaged meat and egg powder, may also influence this decision.

Consequences of Easing Marketing and Price Constraints

Livestock products are perishable and require refrigerated storage and transport to facilitate their marketing, particularly in tropical countries.[35] Well-organized slaughterhouses are often located in or around urban areas, and the rural population does not have easy access to them. Thus in those developing countries where infrastructure facilities are not developed, output growth, and consequently consumption growth, have been constrained.

Taking, for example, the basic data considered earlier for the early 1960s and mid-1970s, consumption of meat increased 3.2 percent a year in the 104 study countries taken as a whole. During the same period, population rose 2.6 percent, resulting in a per capita increase in meat consumption of 0.6 percent a year. As per capita incomes grew at 3.4 percent, the implied overall demand elasticity came close to 0.2. Cross-section studies show, on the other hand, a much higher average income elasticity of demand for meat. Without the supply constraints, consumption would have grown even faster. The story is similar for milk and eggs. With increasing per capita incomes and improved infrastructure development, either through public or private investment, marketing constraints could be eased, leading to more rapid growth in output and consumption of livestock products in the future.

In countries where the higher demand for livestock products resulting from rising per capita incomes and increasing urbanization cannot be met by increased domestic supplies, prices of these products rise. This happens particularly when domestic supplies cannot be fully augmented through imports because of limitations of trade in these commodities, such as trade barriers, perishability, and storage and handling problems. A recent study in the Philippines found significant negative own-price elasticities for meat. Moreover, demand of lower-income groups was much more price responsive than that of higher income groups.[36] If the constraints on trade were not operating, the growth in consumption would have been more rapid.

Improvements in Feeding Efficiency and the Feeding Ratio

The assessment of expected growth in cereal feed use in 1990 and 2000 under alternative assumptions in the preceding chapter was beset with difficulties, partly because inadequate data precluded a better understanding of the processes through which increases in derived demand for feed take place. With the adoption of improved breeding and scientific feeding practices, feeding efficiency increased and feeding ratio declined over time in some of the developed countries with relatively more advanced livestock production systems. On the other hand, in the developing countries, aggregated data show increases in the feeding ratio if only feedgrain is taken into consideration.

Improved breeding and scientific feeding have reduced the feed input-output ratio for each species within a specific production

[34] When world prices of milk powder are low, many developing countries may not have comparative advantage in encouraging domestic production of milk. Still, several countries do so, and the reasons for this should be studied further.

[35] The problem of perishability of livestock products may be partly overcome through trading in live animals; however, such transport over long distances and across international borders raises another set of problems.

[36] B. Ragalado, "The Distributional Impact of Food Policies on Human Nutrition in the Less Developed Countries—The Case of the Philippines," (M.S. thesis, University of the Philippines at Los Baños, 1984).

system. However, modern livestock production systems based on intensive grain feeding are gradually replacing traditional scavenging systems in developing countries. Moreover, there has been a gradual shift in the output mix away from beef production toward poultry, pork, and dairy products. These two factors have gradually led to higher feeding ratios. In the long run, however, feed efficiency could improve in the developing countries also. This will tend to reduce the prices of livestock products, thus increasing the demand for them and also the derived demand for feed. Therefore, even if the direct effect of improving feed efficiency is to reduce the overall feed demand, the indirect effect will be offsetting.

In developed countries more cereal grains are used for feed than directly for food. It is clear that with rising per capita incomes, this phenomenon will extend to developing countries, as has already occurred in a number of Third World countries. An assessment of the extent of this change and how long it will take is difficult. The small proportion of feed use in total domestic utilization of cereals at present holds down the weighted average income elasticity in several of the developing countries. However, the weighted average elasticity, based on empirical data for the countries discussed in Chapter 6, does not allow for changing feeding ratios. When these feeding ratios increase rapidly, either because of changes in the composition of meat or changes in feed components and their relative prices, the weighted average elasticity will also rise.

In some countries of Latin America where current levels of meat consumption are already high, the income elasticity of demand for meat is relatively low, but higher than that for cereals for food, because the income elasticity for cereal feeds declines less rapidly than that for food.[37] In these countries, the combined (weighted) elasticity of cereal demand for food and feed is not very high. On the other hand, in countries where per capita income growth, income elasticity of meat, and feeding ratios are all high, rapid expansion in cereal feed use can be expected, as in Taiwan and the Republic of Korea. The projected cereal feed use in 2000 would give a feeding ratio ranging from 2.9 to 3.4 for all the Third World countries taken together, as compared to a developed-country average of 3.6 in 1980.

The Relationship Between Livestock Development Strategy and Feed Demand

The derived demand for feed depends upon the composition of livestock output and the strategy for livestock development that is adopted. If poultry and pig raising and the dairy industry are encouraged, and thus grow more quickly, the demand for concentrate feeds with grain components could be even larger. Also, if more commercial and semicommercial enterprises develop for livestock industry expansion, the growth in grain-based feed demand may be much more rapid than it would be if development is organized through rural cooperatives or other forms of labor-intensive production strategies. In the latter case, greater use could be made of locally available agricultural by-products and wastes, leading to reduction in costs and hence to larger consumption of livestock products.

Coarse grains are often grown on poor soils by small farmers, and the higher demand for such grains could result in increased incomes for the poor.

Larger Use of By-Products and Wastes

It is likely that many agricultural by-products and wastes, though available, are not at present being utilized as livestock feed, partly because their bulkiness and the scattered nature of agricultural production result in high collection costs, and partly because of lack of knowledge regarding their suitability for feed use. However, the potential for their increased use in the future

[37] John W. Mellor, "Third World Development: Food, Employment and Growth."

exists. In some cases, these products may need further processing for which the technology may not now be available. Though the compound feed industries in developing countries "generally follow the technology evolved in developed countries, there are no technical reasons to prevent the use of larger amounts of locally available noncereal feed compounds."[38] Developing countries may need to spend more resources on development of technology to enable greater use of such materials. In addition, governments may have to offer price and other incentives to encourage their use. These questions need further study in the context of rapidly growing feed demand.

Cereal Feed Use and Food Security

Although IFPRI projections are based on constant relative price assumptions, realized feed demand will depend upon a host of other factors including food prices, feeding ratios, and so forth. For developing countries, the use of grains as livestock feed has food security implications. In several of these countries, feedgrains are diverted to food use in drought years, adversely affecting livestock numbers and output. This has implications for short-term food security, medium-term nutrition, and income and employment, particularly for small farmers for whom livestock is a major source of livelihood. Livestock is treated as a store of wealth and a source of savings in African countries. It is a hedge against crop failure, though in drought years losses in livestock are more widespread, and it may take two to five years for farmers to recoup their losses.

Even if part of Third World deficits in meat and milk are met with imports from developed countries, the derived demand for cereal feed in the developed countries would increase, reducing the overall quantities available for direct consumption. As was explained in *Livestock Products in the Third World*, coarse grains are directly consumed as food in developing countries, and their increased feed use could mean a diversion from food use. Competition between the two uses may result in higher prices, which would cause hardship to the most vulnerable population groups. Moreover, a food-feed competition for the use of grains may develop not only between the rich and the poor people within a country, but also between the richer and poorer countries.[39] As Yotopoulos observes, "In the traditional food-feed controversy, animals competed with people for feed versus food. The modern variant has retained this aspect through competition for land. But another dimension has been added: people who compete with people for the indirect versus direct consumption of cereals. In this competition between the rich and poor, relative affluence for the first time has become one of the great claimants on world food supplies."[40]

Need for Research and Improved Data

In the middle and high-income developing countries, with fewer foreign exchange constraints, deficits in cereals for feed could be met from imports, but in other countries special measures are needed to meet the shortage by increasing domestic production of feedgrains or by substituting other feeds. Food, feed, and livestock policies, including incentives and infrastructure development, need to be reviewed and modified where necessary. Improvements in yields of feedgrains and feed efficiency through emphasis on research and development of feed technology could also partly alleviate the situation. Promoting cultivation of feedgrains, especially coarse grains, can be justified from an equity standpoint because coarse

[38] Food and Agriculture Organization of the United Nations, *Changing Patterns and Trends in Feed Utilization* (Rome: FAO, 1983).
[39] Sarma and Yeung, *Livestock Products in the Third World*.
[40] Yotopoulos, "Middle-Income Classes and Food Crises."

grains are usually grown on poorer lands by poor farmers. In addition, the scope for substitution of noncereals, such as cassava supplemented by proteins, for cereals in concentrate feeds needs to be explored. For example, in some of the developing countries where cassava is grown, such substitution becomes feasible with higher yields and lower unit costs of cassava production. Nevertheless, demand for feeds and fodder is likely to increase rapidly in the coming decades, resulting in increased competition for land. Land will have to be used more intensively, and more attention will have to be given to studies on new sources of feed, greater use of by-products and agricultural wastes, and compound feeds. This means that more resources will have to be allocated to research on feeds and fodder at both national and international levels.

A basic problem in analyzing feed trends is the lack of reliable data on feed use. It is therefore important that developing countries take steps—perhaps in cooperation with FAO and with their technical assistance where necessary—to collect and publish regular data on livestock feed and fodders. In the case of cereal feeds, two distinct feed sectors must be included: the first is grains used in feed manufacturing industries, both small- and large-scale. It should be relatively easy to collect these data from feed manufacturers' associations or other related organizations. Second and more difficult are data on grains used directly as feed by farmers out of their home-grown produce or local purchases. These estimates have to be based on household or farm business surveys. Another area in which available data are inadequate is the utilization of feeds by type of livestock output. In view of the rising importance of livestock feed, concerted efforts are needed to fill these data gaps quickly.

APPENDIX 1: DATA AND METHODOLOGY

The data on use of cereals for livestock feed and on livestock numbers and output used in the study are taken from the international data base of FAO. The annual data on cereals used as feed for the years 1966-80 are from the FAO "Agricultural Supply/Utilization Accounts Tape" for 1981. Statistics of livestock numbers for 1980 are from the *FAO Production Yearbook, 1982.* Other data on livestock output are obtained from the FAO "Production Yearbook Tape, 1981." Projections of output and consumption of livestock products to 1990 and 2000 are based on IFPRI Research Report 49, by J. S. Sarma and Patrick Yeung, *Livestock Production in the Third World: Past Trends and Projections to 1990 and 2000,* 1985. The sources of other data, such as trade and prices, are quoted under their respective tables.

Past Trends

The methodology approach taken in this report is first to analyze the past trends of the variables, which are based on annual averages for the two five-year periods 1966-70 (late 1960s) and 1976-80 (late 1970s) for individual countries or subregions. These averages are used for absolute measures of change and relative distributions. The annual growth rates calculated for this period represent the compound growth rates between the mid-years of the two quinquennia.

In addition, trend growth rates of cereal feed are also calculated using the exponential growth equation fitted to the annual data on feed use; trend values for 1966 and 1980 are worked out for each country and subregion. The trend growth rates for the regions and other aggregates are based on the aggregate trend values at the beginning and end of the period, using the formula

$$Y_t = Y_o(1 + r)^t,$$

where Y_o and Y_t are the trend estimates of the variable in the base period (o) and the end year (t), and r represents the annual growth rate of the variable.

Projections of Feed Use

Projections of feed use to 1990 and 2000 are made using five alternative methods.

Method 1

This method is based on the assumption that the projected feed use of cereals in 1990/2000 equals the projected output of livestock products in 1990/2000 multiplied by the corresponding projected feeding ratio.[41] Output of meat, milk, or eggs is projected as an extrapolation of 1961-77 trends of each of these products in each of the 104 developing countries included in the study. These data are taken from *Livestock Products in the Third World* at the country level and have been aggregated at the subregional level.

The projected outputs are converted into Livestock Output Units (LOUs), using the formula: meat + 1/10 of milk + eggs for each subregion.

Annual values of feeding ratios for the period 1966-80 are computed, and linear trends are fitted to them. Projected trend values of these ratios for 1990 and 2000 are then obtained. The product of the pro-

[41] Hereafter, the term feed use relates to cereal feeds only; trends relate to exponential time trends.

jected output of livestock products and the corresponding feeding ratio gives the projected feed use.

Method 2

This method assumes that the difference between the growth rate in feed use and that in livestock output in each subregion will continue to 1990 and 2000. The growth rates implied in the livestock output projections for 1990/2000 over the 1980 trend level were first calculated for each subregion. Then the difference between the 1966-80 trend growth rate of feed use and that of livestock output in the subregion during the same period was computed. This difference was added to the 1980-1990/2000 growth rate of livestock output, and the adjusted growth rates in feed use were obtained. The trend value of feed use in 1980 was projected to 1990/2000 using the adjusted growth rate for each subregion.

$$R_{cf}\ 1980\text{-}1990/2000 = r_{cf}\ 1966\text{-}80 - r_{lp}\ 1966\text{-}80 + R_{lp}\ 1980\text{-}1990/2000,$$

where

R_{cf} = the adjusted growth rate in feed use over 1980-1990/2000,

r_{cf} = the growth rate in feed use for 1966-80,

r_{lp} = the growth rate in livestock output for 1966-80, and

R_{lp} = the projected growth rate in livestock output for 1980-1990/2000.

$$\text{Projected feed use in 1990/2000} = \text{Trend value of feed use in 1980} \times (1 + R_{cf})^{10/20}.$$

This is done for each subregion, and the data for the 10 subregions are then aggregated.

Method 3

This method assumes that the trend growth rate for feed use in each subregion over the 1966-80 period is extrapolated to 1990 and 2000.

$$\text{Projected feed use in 1990/2000} = \Sigma_{(\text{subregions})}\ \text{Trend value of feed use in each subregion in 1980} \times (1 + r_{cf})^{10/20},$$

where r_{cf} has the same meaning as above.

Method 4

In this method, trend growth rates in feed use in each of the 29 countries in which feed use exceeds 500,000 tons in 1980 are extrapolated. For the remaining 75 countries, these are grouped into four classes according to the level of per capita income, and the trend growth rate of feed use in each of the four classes is used in projecting the feed use. These two sets of figures are aggregated to give the projected feed use in 1990/2000.[42]

Method 5

In method 5, the income elasticity of demand for meat is used as a proxy for that of cereal feed. Thus the projected feed use takes into account the rise in population and per capita income growth; the latter is based on the continuation of 1966-80 trends in per capita income.

$$\text{Projected feed use in 1990/2000} = \text{Trend value of cereal feed use in 1980} (1 + r_p)^{10/20} \times (1 + r_y \times \eta_m)^{10/20},$$

[42] An upper limit of 10 percent has been imposed in extrapolating the individual country growth rates in feed use.

where

r_p = the rate of population growth,

r_y = the rate of per capita income growth,[43] and

η_m = the income elasticity of demand for meat.

All these projections assume constant relative prices. These are computed for each country and aggregated for the 104 developing countries. This is the method adopted in the IFPRI research report *Food in the Third World.*

[43] A lower limit of 0.5 and an upper limit of 6.0 percent were imposed on the growth rates of per capita income.

APPENDIX 2:
CLASSIFICATION OF COUNTRIES SELECTED FOR THE STUDY

Table 20—Classification of developing countries by per capita income, income growth, and livestock output growth

Region/Subregion/Country	1980 GNP Per Capita				1961-80 Growth of GNP Per Capita				Growth of Livestock Output			
	Less Than $250	$250-$499	$500-$1,999	2,000 or More	Less Than 1 Percent	1.0-2.9 Percent	3.0-4.9 Percent	5 Percent or More	Less Than 1 Percent	1.0-2.9 Percent	3.0-4.9 Percent	5 Percent or More
Asia												
South Asia												
Bangladesh	x				x					x		
Bhutan	x				x					x		
India	x					x					x	
Nepal	x				x					x		
Pakistan		x				x					x	
Sri Lanka		x				x			x			
East and Southeast Asia												
Burma	x					x				x		
Fiji			x				x				x	
Hong Kong				x				x				x
Indonesia		x					x					x
Kampuchea	x				x				x			
Korea, Democratic People's Republic of			x				x					x
Korea, Republic of			x					x				x
Laos	x					x				x		
Malaysia			x				x				x	
Mongolia			x				x			x		
Papua New Guinea			x			x					x	
Philippines			x			x					x	
Singapore				x				x				x
Thailand			x				x				x	
Vietnam	x				x						x	

North Africa/Middle East													
Northern Africa													
Algeria				x			x				x		
Egypt			x				x			x			
Libya				x			x					x	
Morocco			x			x				x			
Sudan		x			x						x		
Tunisia			x				x				x		
Western Asia													
Afghanistan	x				x				x				
Cyprus				x				x			x		
Iran				x				x				x	
Iraq				x				x			x		
Jordan			x					x			x		
Kuwait				x	x							x	
Lebanon			x				x		x				
Oman				x				x		x			
Saudi Arabia				x				x				x	
Syria			x				x					x	
Turkey			x				x				x		
Yemen Arab Republic			x					x		x			
Yemen People's Democratic Republic		x						x		x			
Sub Saharan Africa													
West Africa													
Benin		x				x					x		
Burkina Faso	x					x			x				
Chad	x				x				x				
Côte d'Ivoire			x			x						x	
Gambia		x					x				x		
Ghana			x		x						x		
Guinea		x				x					x		
Guinea-Bissau	x				x					x			
Liberia			x			x					x		
Mali	x					x			x				
Mauritania		x				x			x				
Niger		x			x				x				
Nigeria			x				x				x		
Senegal		x			x						x		
Sierra Leone		x				x					x		
Togo		x				x					x		

Table 20—Continued

Region/Subregion/Country	1980 GNP Per Capita				1961-80 Growth of GNP Per Capita				Growth of Livestock Output			
	Less Than $250	$250-$499	$500-$1,999	2,000 or More	Less Than 1 Percent	1.0-2.9 Percent	3.0-4.9 Percent	5 Percent or More	Less Than 1 Percent	1.0-2.9 Percent	3.0-4.9 Percent	5 Percent or More
Central Africa												
Angola			x		x					x		
Burundi	x					x						x
Cameroon			x			x						x
Central African Republic		x			x						x	
Congo			x			x						x
Gabon				x				x				x
Rwanda	x					x						x
Zaire	x				x					x		
Eastern and Southern Africa												
Botswana			x					x			x	
Ethiopia	x					x			x			
Kenya		x				x					x	
Lesotho			x					x	x			
Madagascar		x			x					x		
Malawi		x					x					x
Mauritius			x			x					x	
Mozambique		x			x					x		
Namibia			x		x				x			
Réunion				x		x					x	
Somalia	x				x					x		
Swaziland			x					x		x		
Tanzania		x				x				x		
Uganda			x		x						x	
Zambia			x		x						x	
Zimbabwe			x		x						x	
Latin America												
Central America and the Caribbean												x
Costa Rica			x				x					
Cuba			x				x			x		
Dominican Republic			x				x				x	
El Salvador			x			x						x
Guatemala			x			x					x	

Haiti	x				x						x	
Honduras			x			x					x	
Jamaica			x			x					x	
Mexico				x			x					x
Nicaragua			x		x							x
Panama			x			x					x	
Trinidad and Tobago				x			x				x	
Upper South America												
Bolivia			x			x						x
Brazil				x				x			x	
Colombia			x				x				x	
Ecuador			x					x				x
Guyana			x			x					x	
Paraguay			x				x			x		
Peru			x		x						x	
Surinam				x				x			x	
Venezuela				x		x						x
Lower South America												
Argentina				x		x				x		
Chile				x	x					x		
Uruguay				x		x			x			
Total	19	19	46	20	27	36	23	18	13	23	44	24

Source: World Bank, "Gross National Product by Country Data Tape, 1961-80," Washington, D.C., 1981; Food and Agriculture Organization of the United Nations, "Production Yearbook Tape, 1981;" Rome, 1982; and United Nations, Department of International Economic and Social Affairs, "World Population Prospects as Assessed in 1982," New York, 1983 (computer printout).

Notes: The income groups are determined by the GNP per capita calculated in U.S. dollars, based on the 1961-80 trend of real GNP. Livestock output is expressed as livestock output units obtained by adding meat plus one-tenth of milk plus eggs. Then the countries are classified according to the 1966-70 to 1976-80 average annual growth rate of this livestock output.

APPENDIX 3: SUPPLEMENTARY TABLES

Table 21—World cereal feed use and total output of cereals by type, 1980

Region/Feed Use/Output	Coarse Grains	Paddy	Wheat	Total Cereals
		(million metric tons)		
World				
Feed use	506	32	143	681
Total output	720	399	446	1,565
All study countries				
Feed use	65	17	18	100
Total output	161	232	96	488
Other developing countries[a]				
Feed use	48	13	13	74
Total output	82	143	55	280
Developed countries[b]				
Feed use	393	2	112	507
Total output	477	24	295	796

Sources: Food and Agriculture Organization of the United Nations, *Production Yearbook, 1982* (Rome: FAO, 1983); and Food and Agriculture Organization of the United Nations, "Agricultural Supply/Utilization Accounts Tape, 1981," Rome, 1982.
Note: Parts may not add to total due to rounding.
[a] This category includes China and 24 small developing countries that were excluded from this study.
[b] Countries are grouped according to the classification system of the Food and Agriculture Organization of the United Nations.

Table 22—Cereal feed use by type, 1980

Commodity	Feed Use	Commodity	Feed Use
	(1,000 meteric tons)		(1,000 metric tons)
Wheat	3,985	Rye bran[a]	55
Wheat flour	108	Oats	827
Wheat bran[a]	13,995	Rolled oats	1
Subtotal for wheat	18,088	Millet	1,113
Paddy	2,317	Millet bran[a]	1,200
Milled rice	274	Sorghum	10,802
Broken rice	17	Sorghum flour	85
Rice bran[a]	13,972	Sorghum bran[a]	812
Rice bran cake[a]	525	Buckwheat	30
Subtotal for paddy	17,105	Buckwheat bran[a]	4
Barley	10,396	Canary seed	59
Maize	35,124	Mixed grain	145
Maize flour	3	Grain not elsewhere specified	285
Maize bran[a]	3,879	Flour not elsewhere specified	20
Maize cake[a]	68	Bran not elsewhere specified[a]	69
Maize gluten[a]	[b]	Subtotal for coarse grains	65,141
Rye	164		
Rye flour	[b]	Total	100,334

Source: Food and Agriculture Organization of the United Nations, "Agricultural Supply/Utilization Accounts Tape, 1981," Rome, 1982.
[a] This is a by-product.
[b] Less than 500 metric tons.

Table 23—World livestock numbers, 1980

Country Group	Cattle and Buffalo	Sheep and Goats	Pigs	Poultry
		(millions)		
World[a]	1,325	1,578	795	6,607
Developed economies	425	552	340	3,159
Developing economies	899	1,026	455	3,448
104 study countries[b]	829	840	132	2,578
Asia	367	223	48	829
North Africa/Middle East	62	265	...	354
Sub-Saharan Africa	131	209	12	433
Latin America	268	143	72	961

Source: Food and Agriculture Organization of the United Nations, *Production Yearbook, 1982* (Rome: FAO, 1983).
Notes: Parts may not add to total due to rounding. The ellipsis indicates a nil or negligible amount.
[a]Countries are grouped according to the classification system of the Food and Agriculture Organization of the United Nations. China is included.
[b] Countries are grouped according to the classification system of the International Food Policy Research Institute. China is excluded.

Table 24—Trends in cereal feed use, by region, 1966-70 and 1976-80

Region	Coarse Grains	Paddy	Wheat	Total Cereals
		(million metric tons)		
Asia				
1966-70	4.83	11.09	2.92	18.84
1976-80	8.39	14.73	5.20	28.32
Growth rate (percent)	5.68	2.88	5.94	4.16
North Africa/Middle East				
1966-70	8.42	0.34	3.81	12.54
1976-80	13.57	0.32	6.66	20.46
Growth rate (percent)	4.88	−0.40	5.73	5.02
Sub-Saharan Africa				
1966-70	2.52	0.21	0.23	2.76
1976-80	3.05	0.27	0.43	3.75
Growth rate (percent)	2.76	2.60	6.50	3.10
Latin America				
1966-70	19.39	0.77	2.87	23.03
1976-80	31.62	1.30	4.49	37.40
Growth rate (percent)	5.01	5.34	4.56	4.97
Total 104 countries				
1966-70	34.96	12.41	9.84	57.21
1976-80	56.63	16.63	16.78	90.03
Growth rate (percent)	4.94	2.97	5.48	4.64

Source: Food and Agriculture Organization of the United Nations, "Agricultural Supply/Utilization Accounts Tape, 1981," Rome, 1982.

Table 25—Cereal feed use of grains and brans and by-products, by region and commodity, 1966-70 and 1976-80

Region/Commodity	Grains		Brans and By-Products	
	1966-70	1976-80	1966-70	1976-80
	(million metric tons)			
Asia				
Coarse grains	2.77	5.79	2.06	2.60
Wheat	0.25	0.45	2.67	4.75
Paddy	1.52	2.11	9.57	12.62
Total	4.54	8.35	14.30	19.97
North Africa/Middle East				
Coarse grains	7.98	13.04	0.44	0.53
Wheat	1.43	2.57	2.38	4.09
Paddy	...	...	0.34	0.32
Total	9.41	15.61	3.16	4.94
Sub-Saharan Africa				
Coarse grains	0.89	1.29	1.44	1.76
Wheat	...	...	0.23	0.42
Paddy	0.09	0.11	0.12	0.16
Total	0.98	1.40	1.79	2.34
Latin America				
Coarse grains	18.58	30.57	0.80	1.05
Wheat	0.69	1.23	2.18	3.26
Paddy	0.02	0.19	0.75	1.10
Total	19.29	31.99	3.73	5.41
All study countries				
Coarse grains	30.22	50.68	4.74	5.94
Wheat	2.37	4.26	7.46	12.52
Paddy	1.62	2.41	10.78	14.21
Total	34.21	57.35	22.98	32.67

Source: Food and Agriculture Organization of the United Nations, "Agricultural Supply/Utilization Accounts Tape, 1981," Rome, 1982.
Note: The ellipses indicate a nil or negligible amount.

Table 26—Cereal feed use and total livestock output, by region and subregion, 1966-70 and 1976-80

Region/Subregion	Cereal Feed Use			Livestock Output[a]		
	1966-70	1976-80	Growth Rate	1966-70	1976-80	Growth Rate
	(million metric tons)		(percent/year)	(million metric tons)		(percent/year)
Asia	18.84	28.32	4.16	7.73	10.94	3.53
South Asia	10.05	13.27	2.82	4.50	6.04	2.99
East and Southeast Asia	8.79	15.05	5.52	3.23	4.90	4.25
North Africa/Middle East	12.57	20.56	5.04	3.88	5.58	3.70
Northern Africa	3.11	5.90	6.62	1.41	1.94	3.23
Western Asia	9.46	14.65	4.47	2.47	3.64	3.96
Sub-Saharan Africa	2.76	3.75	3.10	3.42	4.24	2.17
West Africa	1.05	1.42	3.07	1.20	1.50	2.24
Central Africa	0.20	0.31	4.31	0.24	0.36	4.15
Eastern and Southern Africa	1.51	2.01	2.96	1.98	2.38	1.86
Latin America	23.03	37.40	4.97	13.24	18.59	3.45
Central America	5.10	10.41	7.40	2.72	4.27	4.62
Upper South America	11.41	19.43	5.47	5.82	8.93	4.37
Lower South America	6.53	7.56	1.48	4.71	5.39	1.39
Total 104 countries	57.21	90.03	4.64	28.27	39.35	3.36

Sources: Food and Agriculture Organization of the United Nations, "Agricultural Supply/Utilization Accounts Tape, 1981," Rome, 1982; and Food and Agriculture Organization of the United Nations, "Production Yearbook Tape, 1981," Rome, 1982.

[a] Livestock output is expressed in livestock output units derived as meat + 1/10 milk + eggs.

Table 27—Production of compound feed, selected developing countries, 1974-76 average and 1980

Country	1974-76 Average	1980
	(1,000 metric tons)	
Argentina	1,100	1,850
Brazil	6,900	11,400
Colombia	290	1,100
Egypt	150	1,640
India	700	1,150
Iran	100	200
Korea, Republic of	1,070	3,500
Malaysia	319	475
Mexico	3,167	4,600
Morocco	80	210
Nigeria	135	400
Peru	320	467
Philippines	747	1,150
Saudi Arabia	15	300
Thailand	700	1,100
Tunisia	130	450
Turkey	484	1,449
Venezuela	1,233	1,700
Other developing countries	2,675	6,562
Total developing countries (excluding China)	20,315	39,703

Source: Food and Agriculture Organization of the United Nations, *Changing Patterns and Trends in Feed Utilization* (Rome: FAO, 1983).

Table 28—Income elasticity of demand for cereals and livestock products, selected countries, 1980 and 2000

Country/Year	Cereals	Beef	Mutton	Pigmeat	Poultry	Cow's Milk (Whole)	Eggs
Brazil							
1980	0.15	0.58	0.29	0.29	0.64	0.45	0.55
2000	0.05	0.45	0.25	0.25	0.46	0.15	0.41
Egypt							
1980	0.04	0.80	0.90	0.70	1.30	1.00	0.70
2000	0.02	0.80	0.90	0.70	1.30	0.59	0.70
India							
1980	0.25	1.20	1.20	0.80	1.50	0.80	1.00
2000	0.23	1.20	1.20	0.80	1.50	0.80	1.00
Indonesia							
1980	0.29	1.50	1.60	0.80	1.50	0.20	1.20
2000	−0.40	1.50	1.60	0.80	1.50	0.20	1.20
Kenya							
1980	0.35	1.00	0.90	0.70	1.20	0.59	1.30
2000	0.02	1.00	0.90	0.70	1.20	0.51	1.30
Korea, Republic of							
1980	0.09	0.80	1.00	0.73	1.00	0.49	0.80
2000	−0.04	0.42	1.00	0.40	1.00	0.24	0.42
Malaysia							
1980	0.14	0.49	0.32	0.41	0.87	0.57	0.73
2000	−0.21	0.49	0.32	0.41	0.52	0.40	0.73
Mexico							
1980	−0.10	0.59	0.69	0.49	0.93	0.68	0.59
2000	−0.10	0.50	0.57	0.43	0.68	0.56	0.50
Nigeria							
1980	0.17	1.20	1.30	1.00	1.00	1.20	1.20
2000	0.15	1.20	1.30	1.00	1.00	1.20	1.20
Philippines							
1980	0.22	1.20	0.90	0.93	1.00	1.50	1.00
2000	0.20	1.20	0.90	0.62	1.00	1.50	1.00
Thailand							
1980	0.06	0.56	0.50	0.47	0.50	0.80	0.50
2000	−0.13	0.41	0.50	0.36	0.50	0.80	0.50
Turkey							
1980	−0.05	0.80	1.00	0.50	1.20	0.80	0.80
2000	−0.47	0.80	1.00	0.50	1.20	0.63	0.80

Source: Food and Agriculture Organization of the United Nations, "Parameters of the Demand Functions, Fifth Run," Rome, April, 1978 (computer printout).

Table 29—Ratio of foodgrains to food and feedgrains, selected countries, 1980 to 2000

Country	1980	1985	1990	1995	2000
Brazil	0.43	0.40	0.38	0.35	0.33
Egypt	0.74	0.71	0.67	0.64	0.60
India	0.90	0.89	0.89	0.88	0.87
Indonesia	0.91	0.89	0.85	0.79	0.71
Kenya	0.83	0.82	0.80	0.79	0.77
Korea, Republic of	0.71	0.67	0.64	0.61	0.58
Malaysia	0.66	0.63	0.59	0.55	0.50
Mexico	0.52	0.49	0.46	0.43	0.40
Nigeria	0.93	0.92	0.90	0.88	0.86
Philippines	0.80	0.78	0.77	0.75	0.74
Thailand	0.77	0.75	0.73	0.71	0.69
Turkey	0.47	0.43	0.37	0.32	0.27

Source: Calculated from computer printouts used in Leonardo A. Paulino, *Food in the Third World: Past Trends and Projections to 2000*, Research Report 52 (Washington, D.C.: International Food Policy Research Institute, 1986).

Table 30—Selected developing countries with cereal feed use exceeding 500,000 metric tons, 1980

Country	Feed Use	Country	Feed Use
	(million metric tons)		(million metric tons)
Algeria	1.06	Malaysia	1.09
Argentina	5.10	Mexico	9.52
Bangladesh	1.73	Morocco	1.41
Brazil	19.37	Nigeria	0.67
Burma	0.98	Pakistan	1.41
Chile	1.22	Peru	0.75
Colombia	1.24	Philippines	1.72
Cuba	1.03	Saudi Arabia	0.98
Egypt	3.13	Syria	1.30
India	9.50	Thailand	2.71
Indonesia	2.48	Tunisia	0.57
Iran	2.78	Turkey	8.81
Iraq	0.74	Venezuela	2.08
Korea, Democratic People's Republic of	2.58	Vietnam	1.02
Korea, Republic of	3.42	Total for 29 countries	90.40
		Total for 104 countries	100.33

Source: Food and Agriculture Organization of the United Nations, "Agricultural Supply/Utilization Accounts Tape, 1981," Rome, 1982.

Table 31—Cereal feed use projections under method 1, 1990 and 2000

Region/Subregion	Trend Value	Projected Cereal Feed Use	
	1980	1990	2000
		(million metric tons)	
Asia	30.69	44.33	68.45
South Asia	14.10	16.67	20.92
East and Southeast Asia	16.59	27.66	47.53
North Africa/Middle East	21.70	33.85	56.33
Northern Africa	6.60	11.80	21.19
Western Asia	15.10	22.05	35.14
Sub-Saharan Africa	4.03	5.77	8.49
West Africa	1.50	1.77	2.46
Central Africa	0.33	0.55	0.89
Eastern and Southern Africa	2.20	3.45	5.14
Latin America	41.66	66.69	111.63
Central America	12.32	22.36	41.79
Upper South America	21.19	34.99	58.94
Lower South America	8.15	9.34	10.90
Total	98.08	150.64	244.89

Sources: Food and Agriculture Organization of the United Nations, "Production Yearbook Tape, 1981," Rome, 1982; Food and Agriculture Organization of the United Nations, "Agricultural Supply/Utilization Accounts Tape, 1981," Rome, 1982; and J. S. Sarma and Patrick Yeung, *Livestock Products in the Third World: Past Trends and Projections to 1990 and 2000,* Research Report 49 (Washington, D.C.: International Food Policy Research Institute, 1985).

Notes: Method 1 is based on projected values of feeding ratios in 1990 and 2000 applied to projected output of livestock products expressed in terms of livestock output units, which are obtained by adding projections for meat + 1/10 milk + eggs. Parts may not add to total because of rounding.

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